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RIO COUNTRY REPORT 2015: Switzerland

Benedetto Lepori

Ivan Ureta

Siegfried Alberton

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Contact information

Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)

E-mail: jrc-ipts-secretariat@ec.europa.eu

Tel.: +34 954488318

Fax: +34 954488300

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Abstract

The 2015 series of RIO Country Reports analyse and assess the policy and the national research and innovation system developments in relation to national policy priorities and the EU policy agenda with special focus on ERA and Innovation Union.

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Foreword

The report offers an analysis of the R&I system in Switzerland for 2015, including relevant policies and funding, with particular focus on topics critical for EU policies. The report identifies the main challenges of the Swiss research and innovation system and assesses the policy responses. It was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc. The quantitative data is, whenever possible, comparable across all EU Member State and associated countries reports. Unless specifically referenced all data used in this report are based on Eurostat statistics available in February 2016.

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Authors' affiliations:

Benedetto Lepori; Center for Organizational Research, Università della Svizzera Italiana

Ivan Ureta; Inno3, Scuola Universitaria Professionale della Svizzera Italiana

Siegfried Alberton; Inno3, Scuola Universitaria Professionale della Svizzera Italiana

Executive summary

This report provides an overview of the Swiss Research and Innovation (R&I) system and has been prepared by Benedetto Lepori (Center for Organizational Research, Università della Svizzera italiana), Ivan Ureta and Siegfried Alberton (Inno3, Scuola Universitaria Professionale della Svizzera italiana).

The report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites, etc. The quantitative and qualitative data is, whenever possible, comparable across all EU Member State reports.

This report covers policy developments until the end of 2015, as well as content from the strategic plan for education, research and innovation released in spring 2016.

Overview of the R&I system. Switzerland enjoyed a stable economic situation in recent years, characterized by low unemployment and stable public finances. The economy is high-tech and export-oriented, with a strong presence of large multinational companies. The R&I system can be characterized by the coexistence of a university-dominated public sector, which strongly focuses on basic research and human resources training, and a strong private R&D sector, which is essentially self-financed and dominated by a small number of large multinational companies who ranking among the top companies worldwide in terms of R&D volume. The political system of governance is highly decentralized due to the federal nature of the country, where cantons have important competences concerning higher education, but also support for innovation and economic development.

Recent developments. Swiss R&I policy is characterized by a high degree of continuity and integration, achieved through the instrument of national strategic plans, where priorities, policy measures and the allocation of funding over four-year periods are defined (the plan for the period 2017-2020 has been released by the Federal Council in spring 2016). Nevertheless, some important reforms have been achieved in recent years at the institutional level: the grouping of all federal competences in the domain of the Ministry of Economic Affairs, the release of a higher education coordination act covering all types of HEIs (Higher Education Institutions), the on-going reform of the Commission for Technology and Innovation (the Swiss Innovation Agency) and the creation of a Swiss Innovation Park. Public policies are less concerned with setting thematic priorities for Swiss R&I, which are largely defined bottom-up by the research actors themselves.

Public and private funding. Swiss R&D is well funded, with the country almost reaching their 3% target for R&D. The funding system is characterized by a clear divide between public funding, strongly oriented towards universities and basic research, and private funding of R&D activities from private companies. The State does not directly support private R&D, but there are indirect instruments through joint projects with public research financed by the Swiss Innovation Agency. Public R&D investment increased consistently in the last two decades, with growth rates well above overall public expenditures. The public funding system is composed by a mix of (weakly competitive) institutional funding (about two-thirds of the total) and competitive project funding (about one-third); the latter is essentially managed by the academic-oriented Swiss National Science Foundation and by the Swiss Innovation Agency (KTI).

Quality of the science base. The Swiss science system is very good, with indicators concerning the volume of publications per inhabitant and the citation impact being among the top countries worldwide. Despite not being part of the European Union, Switzerland is strongly involved in most international and European programs, including COST, EUREKA and ESA. Switzerland became fully associated with EU-FPs in 2004, but the association was suspended in 2014 due to the acceptance of a popular initiative for limiting immigration of workers. After continuing negotiations, Switzerland is currently partially associated with Horizon 2020 (1st pillar and actions under "Spreading Excellence and Widening Participation"), Euratom and ITER from 15 September 2014 to 31

December 2016. The country also has an active cooperation policy in research with third countries. A specific strength of the Swiss system is the open and competitive academic labour market, which is highly attractive internationally – almost half of the research personnel in Swiss universities has a foreign nationality. Swiss universities are able to train a large number of PhD graduates, which are largely hired by companies for their research activities.

Framework conditions for R&I and science business cooperation. Despite high wages and costs, Switzerland remains a very attractive country for private R&I, thanks to their solid infrastructure, provision of skilled labour and low taxation rates. While the Swiss R&I policy is based on complementarity between the public and private sector, where innovation is essentially the responsibility of companies, an entire set of measures has been implemented in previous decades to promote knowledge transfer (for example the newly created Swiss innovation park), entrepreneurship and risk capital. Collaborations between universities and private companies are strong and based on personal ties and flows of the people; since 2000, the creation of Universities of Applied Sciences and the reinforcement of the Swiss Innovation Agency have provided more favourable conditions to support innovation, also in SMEs.

Challenges. Despite the strong appreciation of the Swiss Franc, the Swiss economy has, until now, maintained a rather favourable situation, with stable growth rates and low unemployment; it remains however a challenge for a country characterized by very high production costs to withstand international competition and to avoid the risk of delocalisation of private R&D. The major uncertainty in this respect is created by the February 2014 vote, where the Swiss population accepted the reintroduction of a quota system for foreign workers. Such a measure would generate difficulties in hiring skilled labour in private companies and render the Swiss research system less attractive internationally. Even more importantly, the quota system might conflict with the EU's free mobility of persons, leading to the denunciation of bilateral agreements that allow Switzerland to access the EU market and research system. Addressing such challenges depends more on the general policy environment than on specific measures concerning R&I policies.

Zusammenfassung

Dieser Bericht beleuchtet das Forschungs- und Innovationssystem in der Schweiz. Die Autoren sind Benedetto Lepori (Zentrum für Organisationsforschung, Università della Svizzera Italiana), Ivan Ureta und Siegfried Alberton (Inno3, Scuola Universitaria Professionale della Svizzera Italiana).

Der Bericht basiert auf einer Reihe von Richtlinien für das Sammeln und Analysieren von Daten, wie Dokumente, Statistiken, Auswertungen, Websites, usw. Die quantitativen und qualitativen Daten wurden, wo immer möglich, mit den Berichten der EU Länder verglichen.

Dieser Bericht befasst sich mit den politischen Entwicklungen bis Ende des Jahres 2015, sowie mit dem Inhalt des im Frühjahr 2016 veröffentlichten strategischen Plans für Bildung, Forschung und Innovation.

Überblick über das Forschungs- und Innovationssystem. Die wirtschaftliche Lage, sowie die öffentlichen Finanzen waren in den letzten Jahren in der Schweiz stabil und die Arbeitslosigkeit war niedrig. Die Wirtschaft ist Hightech- und Exportorientiert, bei einer starken Präsenz von multinationalen Unternehmen.

Das Forschungs- und Innovationssystem kann durch eine enge Zusammenarbeit zwischen dem öffentlichen- und dem privaten Sektor charakterisiert werden. Der öffentliche Sektor wird durch die Universitäten dominiert, und diese fokussieren sich stark auf die Grundlagenforschung und die Ausbildung. Der starke private Sektor ist hauptsächlich selbst-finanziert und von einer kleinen Anzahl Grosskonzerne dominiert. Die Forschungs- & Entwicklungsausgaben dieser Grosskonzerne zählen zu den grössten weltweit.

Das föderalistische System der Schweiz führt zu einer Dezentralisierung; die Kantone haben dadurch eine hohe Kompetenz im Bereich Hochschulwesen, Innovationsförderung und Wirtschaftsentwicklung.

Jüngste Entwicklung. Die schweizerische Forschung und Innovationspolitik ist in hohem Mass durch Kontinuität und Integration gekennzeichnet. Durch die nationalen strategischen Pläne werden die Prioritäten, Massnahmen sowie die Verteilung der Mittel über einen Zeitraum von 4 Jahre festgelegt (der Plan für die Periode 2017-2020 wurde vom Bundesrat im Frühjahr 2016 verabschiedet).

Es wurden in den letzten Jahren einige wichtige institutionelle Reformen verabschiedet: die Zusammenführung aller eidgenössischen Kompetenzen im Amt für wirtschaftliche Angelegenheiten, die Einführung des Hochschulförderungs- und Koordinationsgesetzes, die Weiterführung der Reform der Kommission für Technologie und Innovation (Swiss Innovation Agency) und den Aufbau eines schweizerischen Innovationsparks. Die thematischen Prioritäten werden hierbei von den Forschern selbst gesetzt und weniger von der öffentlichen Hand.

Die öffentliche und private Finanzierung. Der schweizerische Forschungs- und Entwicklungsbereich ist kapitalstark, und dessen Ausgaben betragen fast 3% des Bruttoinlandproduktes.

Das Finanzierungssystem ist gekennzeichnet durch eine klare Aufteilung zwischen öffentlichen Mitteln, die hauptsächlich Universitäten und Grundlagenforschung unterstützen, und privatwirtschaftliche Forschungs- und Entwicklungsausgaben.

Im Bereich Forschung und Entwicklung bietet der Staat keine direkte Unterstützung an die Privatwirtschaft. Es gibt aber indirekte Instrumente wie gemeinsame Projekte. Der Bund koordiniert seine Beiträge über die schweizerische Innovationsagentur (KTI).

Das öffentliche Forschungs- und Entwicklungsbudget ist in den letzten zwei Jahrzehnten konstant gestiegen, und zwar mit signifikant höheren Wachstumsraten als die allgemeinen öffentlichen Ausgaben.

Die Gelder der öffentlichen Hand fließen zu ca. 2/3 in schwach innovativen Projekte und ca. 1/3 in innovative Arbeiten: die letzteren werden vom Schweizerischen Nationalfond und von der KTI vergeben.

Qualität der Wissenschaft.

Die schweizerische Wissenschaft ist auf hohem Niveau und gehört, betreffend Publikationsvolumen pro Einwohner und Anzahl wissenschaftlicher Zitierungen, zu den besten Ländern weltweit.

Obwohl nicht Teil der Europäischen Union, ist die Schweiz stark in die meisten europäischen und internationalen Programmen eingebunden, einschliesslich COST, EUREKA und ESA.

Die Schweiz wurde im Jahre 2004 Vollmitglied der EU-FPs, musste aber infolge des Abstimmungsergebnisses der Volksinitiative der Personenfreizügigkeit 2014 wieder austreten.

Nach zähen Verhandlungen ist die Schweiz wieder teilassoziiert mit Horizont 2020 (erste Säule und Aktionen zur „Förderung der Exzellenz und Ausweitung der Teilnahme“), Euratom und INTER (15. September 2014 bis 31. Dezember 2016). Somit hat das Land wieder eine aktive Kooperation mit Drittländern. Der offene und wettbewerbsfähige akademische Arbeitsmarkt in der Schweiz ist international äusserst attraktiv – fast die Hälfte der Forscher an den Universitäten hat eine ausländische Nationalität. Schweizer Universitäten bilden eine grosse Anzahl von Akademikern aus, welche dann gerne von Firmen für deren Forschungsaktivitäten eingestellt werden.

Rahmenbedingungen für Forschung-, Innovation- und Wissenschaftskooperation.

Trotz der hohen Löhne und Lebensunterhaltungskosten bleibt die Schweiz ein attraktives Land für die private Forschung und Entwicklung. Dies dank stabiler Infrastrukturen, professionellem Fachpersonal und niedrigen Steuersätzen.

Die Komplementarität zwischen öffentlicher und privater Politik mit starker Federführung der Unternehmen in der Innovation, hat in den früheren Jahrzehnten eine Reihe von Massnahmen ermöglicht, die den Wissenstransfer (z.B. der neu geschaffene Innovationspark), Unternehmertum und Risikokapital gefördert haben.

Die starke Zusammenarbeit zwischen Hochschulen und Unternehmen basiert auf Strömen von Menschen und persönliche Beziehungen. Seit dem Jahr 2000, mit der Schaffung der Fachhochschulen und der Stärkung der schweizerischen Innovationsagentur, haben sich die Rahmenbedingungen zur Förderung der Innovation günstig weiterentwickelt, auch für KMUs.

Herausforderungen. Trotz starker Frankenaufwertung konnte die Schweiz, bis heute, einen stabilen Wirtschaftswachstum und eine niedrige Arbeitslosigkeit beibehalten können.

Es gilt jedoch nun trotz der hohen Produktionskosten im internationalen Vergleich wettbewerbsfähig zu bleiben und eine Abwanderung der privaten Forschungs- und Entwicklungsaktivitäten zu vermeiden.

Diesbezüglich ist die grösste Unsicherheit durch die Auswirkungen der Volksabstimmung vom Februar 2014 gegeben. Die Wiedereinführung der Quotenregelung schränkt die Einstellung von hoch ausgebildeten ausländischen Arbeitnehmern durch privaten Unternehmungen ein und senkt somit die Attraktivität des schweizerischen Forschungssystems im internationalen Vergleich.

Darüber hinaus, ist die Quotenregelung möglicherweise im Widerspruch mit dem Abkommen der Personenfreizügigkeit zwischen der Schweiz und den EU-Staaten, was zur Kündigung der gesamten bilateralen Abkommen führen könnte, welche unter anderem auch den Zugang zum EU-Markt und dessen Forschungssystem ermöglichen. Die Adressierung solcher Herausforderungen hängt mehr von den allgemeinen

politischen Rahmenbedingungen ab, als von spezifischen Forschungs- und Innovationsmassnahmen.

Resumé

Ce rapport donne un aperçu du système suisse de recherche et innovation (R&I). Il a été préparé par Benedetto Lepori (Centre de recherche sur les organisations de l'Université de la Suisse italienne USI), Ivan Ureta et Siegfried Alberton (Inno3, Haute École Spécialisée du Tessin SUPSI).

Le rapport a été préparé sur la base de directives standardisées pour la collecte et l'analyse de différentes sources, y compris des documents politiques, des statistiques, des rapports d'évaluation, des sites web, etc. Les données quantitatives et qualitatives sont, dans la mesure du possible, comparables dans tous les rapports sur les États Membres de l'UE.

Ce rapport couvre les développements politiques jusqu'à la fin de 2015, ainsi que le contenu du plan stratégique pour l'éducation, la recherche et l'innovation publié au printemps 2016.

Une vue d'ensemble du système de R&I. La Suisse a joui dans les dernières années d'une situation économique stable, un faible taux de chômage et des finances publiques saines. L'économie est orientée vers les technologies avancées et les exportations, avec une forte présence de grandes sociétés multinationales. Le système de R&I peut être caractérisée par la combinaison entre un secteur public dominé par les hautes écoles, qui est fortement orienté vers la recherche fondamentale et la formation des ressources humaines, et un secteur privé à haute intensité de R&D, essentiellement autofinancée et où un rôle central est joué par un petit nombre de grandes sociétés multinationales, qui se rangent parmi les premières entreprises mondiales en termes de volume de R&D. La gouvernance du système politique est fortement décentralisée en raison de la nature fédérale du pays, où les cantons disposent de compétences importantes concernant l'enseignement supérieur, mais aussi le soutien à l'innovation et le développement économique.

L'évolution récente. La politique suisse de R&D se caractérise par une grande continuité et par un bon niveau de cohérence systémique, réalisées par l'intermédiaire de l'instrument des plans stratégiques nationaux, où les priorités, les mesures politiques et l'affectation des fonds sur une période de quatre ans sont définies (le plan pour la période 2017-2020 a été publié par le Conseil fédéral au printemps 2016). Néanmoins, certaines réformes importantes ont été réalisées au cours des dernières années au niveau institutionnel: le regroupement de toutes les compétences fédérales dans le domaine dans le Ministère de l'économie, l'entrée en vigueur de la loi sur la coordination de l'enseignement supérieur couvrant tous les types d'établissements d'enseignement supérieur, la réforme en cours de la Commission pour la technologie et l'innovation (l'Agence suisse pour l'innovation) et la création d'un parc de l'innovation. Les politiques publiques sont par contre moins concernées par la définition de priorités thématiques, qui est largement laissée aux décisions autonomes des acteurs du système de la recherche.

Le financement public et privé. Le système suisse de R&D est bien financé, le pays atteignant presque l'objectif de 3% du PIB dédié à la R&D. Le système de financement est caractérisé par une claire séparation entre le financement public, orienté vers les universités et la recherche fondamentale, et le financement privé de la R&D des entreprises. L'État ne finance pas directement la recherche des entreprises, mais la soutient par des instruments indirects comme des projets conjoints avec des acteurs publics de recherche financés par l'Agence suisse de l'innovation. Les dépenses publiques de R&D ont augmenté constamment au cours des deux dernières décennies, avec des taux de croissance bien au-dessus de l'ensemble des dépenses publiques. Le système de financement public est composé par une combinaison entre un financement institutionnel relativement peu compétitif (environ les 2/3 du total) et le financement de projets compétitifs (environ 1/3). Ce dernier bénéficie largement les hautes écoles et est géré par le Fonds National Suisse pour la Recherche Scientifique et par l'Agence suisse de l'innovation.

La qualité de la base scientifique. Le système scientifique suisse est très bon, la Suisse étant parmi les meilleurs pays au niveau mondial pour ce qui concerne le volume de publications par habitant et le nombre de citations. Même si elle n'est pas membre de l'Union européenne, la Suisse est fortement impliquée dans la plupart des programmes internationaux et européens, y compris COST, EUREKA et l'ESA. La Suisse est associée au programme-cadres de R&D de l'UE depuis 2004, mais l'accord d'association n'a pas été renouvelé pour Horizon 2020 en raison de l'acceptation d'une initiative populaire qui prévoit de limiter l'immigration de travailleurs étrangers. A l'issue de nouvelles négociations, la Suisse est actuellement partiellement associée à Horizon 2020 (1er pilier et actions au titre de "propager l'excellence et d'élargir la participation"), à Euratom et à ITER à partir du 15 septembre 2014 est jusqu'au 31 décembre 2016. Le pays a également une politique de coopération active dans le domaine de la recherche avec des pays tiers. Une force spécifique du système suisse est l'ouverture internationale du marché du travail pour les chercheurs, qui est très attractif au niveau international - près de la moitié des chercheurs dans les universités suisses n'a pas la nationalité suisse. Les universités suisses sont en mesure de former un grand nombre de docteurs recherche, qui sont en grande partie embauchés par les entreprises pour leurs activités de recherche.

Conditions-cadre pour la R&I et pour la coopération entre la recherche publique et les entreprises. Malgré les salaires élevés, la Suisse reste un pays très attractif des investissements privés en R&I, grâce à une bonne infrastructure, au niveau élevé des qualifications de la main-d'œuvre et aux faibles taux d'imposition fiscale. La politique de R&I est fondée sur la complémentarité entre le secteur public et le secteur privé, où l'innovation est essentiellement du ressort des entreprises ; en même temps, un ensemble de mesures a été mis en œuvre dans les dernières décennies pour promouvoir le transfert de connaissances, comme le parc de l'innovation suisse nouvellement créé, pour favoriser l'entrepreneuriat et améliorer la disponibilité de capital de risque. Les collaborations entre universités et entreprises privées sont solides et fondées sur les liens personnels et les flux de personnes ; la création des hautes écoles spécialisées et le renforcement de l'Agence de l'innovation ont généré depuis 2000 un meilleur soutien à l'innovation dans les PME également.

Défis. En dépit de la forte appréciation du franc suisse, l'économie suisse a jusqu'à présent maintenu une situation plutôt favorable, avec des taux de croissance stables et un faible taux de chômage. Il demeure toutefois un défi pour un pays qui est caractérisé par des coûts de production très élevés de faire face à la concurrence internationale et d'éviter le risque de délocalisation des investissements privés en R&D. Le principal élément d'incertitude à cet égard est représenté par le résultat du vote de février 2014, où la population suisse a accepté la réintroduction d'un système de quotas pour les travailleurs étrangers. Une telle mesure risquerait de générer des difficultés pour le recrutement de main-d'œuvre qualifiée dans des entreprises privées et de rendre le système de recherche suisse moins attrayant à l'échelle internationale. En outre, le système de quotas pourrait être incompatible avec l'accord avec l'Union européenne sur la libre circulation des personnes. Dans le pire des cas, cela emmènerait à la dénonciation des accords bilatéraux avec l'Union européenne, qui permettent à la Suisse l'accès au marché communautaire et aux programmes-cadres de R&D. Relever ces défis dépend toutefois davantage de la politique générale plutôt que de mesures spécifiques concernant le domaine de la R&I.

1. Overview of the R&I system

1.1 Introduction

Switzerland is a middle-size country located in the heart of Europe, with a population of slightly more than 8 million inhabitants, i.e. about 4% of the EU-28 population.

Switzerland enjoys a favourable and stable economic situation: the GDP per capita is about two times the EU-28 average, while the unemployment rate is only slightly above 4%, i.e. less than half of the EU-28 average. The macroeconomic situation has been stable in recent years, with a real GDP growth rate of between 1% and 2% since 2010. The country therefore overcame the financial crisis of 2009 better than most EU member states, and the economy was also affected to a limited extent by the strong appreciation of the national currency against the euro from 1.6 CHF per euro in 2008 to the current exchange rate of around 1.1.

Like in most other European countries, the economic structure is currently dominated by services, which account for about 70% of the total value added, with a particularly strong presence of financial services, banking, tourism and commodity trading. The whole economy is largely oriented towards high technology in manufacturing and knowledge-intensive services. The substantial manufacturing sector is characterized by the presence of leading multinational companies in sectors like food (Nestlé), pharmaceutical (Novartis and Roche), and mechanical engineering (ABB). The whole economy is strongly export-oriented (exports of goods and services exceeded 70% of the GDP against 45% of the EU-28 average in 2013).

An important component of the economic competitiveness of the country is its excellent physical and service infrastructure – Switzerland ranks first in the global competitiveness report (Schwab and Sala-i-Martin 2015) – and the lean State sector: the State share of GDP is only slightly above 30%, as compared with about 50% in the EU-28, government debt is the lowest among European countries and public finances are balanced, with only marginal yearly deficits and surpluses. This has also created room for increasing public investment in tertiary education and R&D to face the recent economic challenges, like the competition from emerging economies, the appreciation of the Swiss franc against the euro and the USD and, finally, the economic crisis in the European Union (see also section 3.2)¹.

Table 1. Main economic indicators

Indicator	2012	2013	2014	EU average*
GDP per capita (EUR current prices)	64,800	63,800		27,300
GDP growth rate	1.10	1.80	1.90	1.30
Budget deficit as % of GDP	-	0.20	-0.30	-2.90
Government debt as % of GDP	36.40			86.80
Unemployment rate as percentage of the labour force	4.20	4.40	4.50	10.20
GERD in €m	15,357			226,120
GERD as % of the GDP	2.96			1.83
GERD (EUR per capita)	1,931			536
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	5.90	5.90		5.60
Employment in knowledge-intensive service sectors as share of total employment	43.40	44.20	n.a.	39.20
Turnover from innovation as % of total turnover				11.90
Value added of manufacturing as share of total value added	30.51			
Value added of high tech manufacturing as share of total value added	11.93			
* 2014 or latest year available				
Data from EUROSTAT or the Swiss Federal Statistical Office				

¹ An excellent introduction to the Swiss Research&Innovation system is provided by the report published by the State Secretariat for Education, Research and Innovation in spring 2016 (SBFI 2016; <http://www.sbfi.admin.ch/themen/01367/02847/index.html?lang=de>).

Switzerland has no explicit policy target for R&D expenditures, also because most of the R&D expenditures are funded by the private sector and therefore are out of the control of the government. Nevertheless, GERD as a percentage of the GDP already approached the 3% target in 2012.

In terms of the R&I system, Switzerland is characterized by a high level of R&D spending, mostly due to private investments from large companies in the pharmaceutical and mechanical sector (see section 1.2.1 below), which largely exceeds the EU-28 average and has been remarkably stable in the previous two decades. Per capita R&D spending is nearly four times the EU-28 average. In terms of innovation performance, Switzerland ranks as the most innovative country in Europe in the European Union Innovation Scoreboard. Switzerland performs well above the EU average for all dimensions and for most indicators, in particular in three indicators: International scientific co-publications, Public-private co-publications and License and patent revenues from abroad (European Commission 2015).

In this generally favourable economic and innovation context, the major uncertainty is represented by their relationship with the European Union. Switzerland is not a member of the European Union and in 1990 voted against membership in the European Economic Area. Since the year 2002, relationships with the European Union are regulated by a set of bilateral agreements dealing with the free mobility of people, trade and access to the EU market, public procurement, and security (including membership in the Schengen space). A specific agreement grants full association of Switzerland in EU Framework Programs and in the Erasmus program for the mobility of students. In spring 2014, Swiss voters accepted a constitutional initiative requiring the reintroduction of quota systems for foreign immigrants, in order to face the rapid increase of immigration after the introduction of free access for EU citizens. It is highly uncertain if the initiative can be implemented in a way that is compatible with the European Union agreement on the free movement of persons; if not, the European Union would have the right to withdraw from the whole package of bilateral agreements. While the initiative leaves three years for implementation, meaning therefore that relationships with the EU have not yet been affected, there have already been some initial negative consequences. Namely, due to the initiative, Switzerland was not able to sign the extension of the free movement of persons to Croatia, which acceded to the EU in 2013. As a consequence, the European Union suspended the association of Switzerland to the Horizon 2020 program and to the Erasmus program. A partial association in Horizon 2020, which grants access for Swiss researchers to European Research Council grants, was signed in 2014 and will last until spring 2017. As a consequence of the initiative, the European Union also blocked ongoing negotiations on other important dossiers for Switzerland, including access to the European electricity market.

1.2 Structure

1.2.1 Main features of the R&I system

The Swiss R&I system can be characterized by a clear distinction of functions, structures and funding flows between the public and the private sector, following the traditional liberal orientation of the Swiss economic policy. At the same time, cooperation between the public and the private sector is strong in terms of publications (more than three times the European average), informal transfer and mobility of human resources (Arvanitis, Kubli and Woerter 2008). Cooperation between public research and SMEs has been strengthened through cooperative projects funded by the Swiss Innovation Promotion Agency (CTI) and through the establishment of Universities of Applied Sciences (UASs) in the 90s.

The public sector is oriented towards basic research and dominated by higher education institutions (HEIs), some of them being among the top-rated international research universities. Its organization is linked to the federal political organization of the country, where cantons have (almost) exclusive competences on policy domains like schooling, police, justice, and healthcare and raise their own taxes. Switzerland is a federal state

and cantons remain a central policy actor in the Swiss State, while the repartition of tasks between cantons and the federal level is a sensible political issue.

As detailed below, research policy in a strict sense is currently a task of the central State, while the role of cantons in the direct funding of R&D is very limited. Governance of higher education is shared via a complex division of tasks between cantons and the federal level; the same pertains to innovation support, where applied R&D and support for technological development are mostly managed by the central State, while support for economic development is mostly a cantonal competence (also since fiscal policy is mostly undertaken at the cantonal level).

1.2.2 Governance

Policy governance. The policy governance of R&I has been strongly affected by the federal structure of the country and has grown from the historical processes which date back to the middle ages, when the first universities were founded (University of Basel 1460). Cantons are solely responsible for the governance of their own university (which are co-financed by the Confederation), while the Confederation created and funds two Federal Institutes of Technology (ETH Zurich in 1872 and EPFL Lausanne in 1969). Universities of Applied Sciences are also cantonal schools, but subject to a federal framework regulation. The governance of the higher education sector has however been deeply revised in the direction of a more cooperative arrangement from 2015 onwards. On the contrary, research policy and research funding are the competence of the Confederation, which provides financial means to the two national funding agencies, i.e. the Swiss National Science Foundation (support to basic research) and the Swiss Innovation Agency (applied research and knowledge transfer; see further section 3.3.1).

Figure 1 provides an overview of the structure of R&I policy governance in Switzerland as of 2015; we further comment on recent policy changes and on-going reforms in section 2.2 of this report.

At the federal level, since 2013, most competences concerning research policy, higher education and innovation promotion are concentrated in the Ministry of Economy. Research and Higher Education Policy is the responsibility of the *State Secretariat for Education, Research and Innovation* (SERI). SERI is in charge of the overall planning and coordination of the Swiss R&I policy; SERI also provides funding to the main national funding agency, i.e. the Swiss National Science Foundation, co-funding of cantonal universities and funding for a number of national programs; it also manages the Swiss participation in international funding agencies and research organizations, as well as the EU Framework Programs.

Within the same department, the Council of the Federal Institutes of Technology (ETH-Rat) is in charge of the governance and steering of the domain of the Federal Institutes of Technology, which is composed by the two federal schools – ETH Zurich and EPFL Lausanne – and by four independent research institutes. Finally, the Swiss Innovation Agency (CTI) is a Federal Commission of experts, which is part of the Department of Economy and which functions as the national funding agency for applied research and cooperation with the private economy.

The State Secretariat for Economy is responsible for economic policy, including innovation policy and regional policy, at the federal level.

The Swiss Science and Innovation Council (SSIC) is the advisory body of the Federal Council (the Swiss federal government) for R&I policy; it functions as a national think-tank fostering the debate on the central issue of the national R&I policy. A similar role is assumed by the four Swiss Academies of Science and Arts, who develop foresight of socially relevant topics and scientific communication to the broader public.

At the cantonal level, competences for higher education policy are usually within the education department, which oversees the respective universities (for the university

cantons) and the cantonal participation in Universities of Applied Sciences (most of them being multi-cantonal).

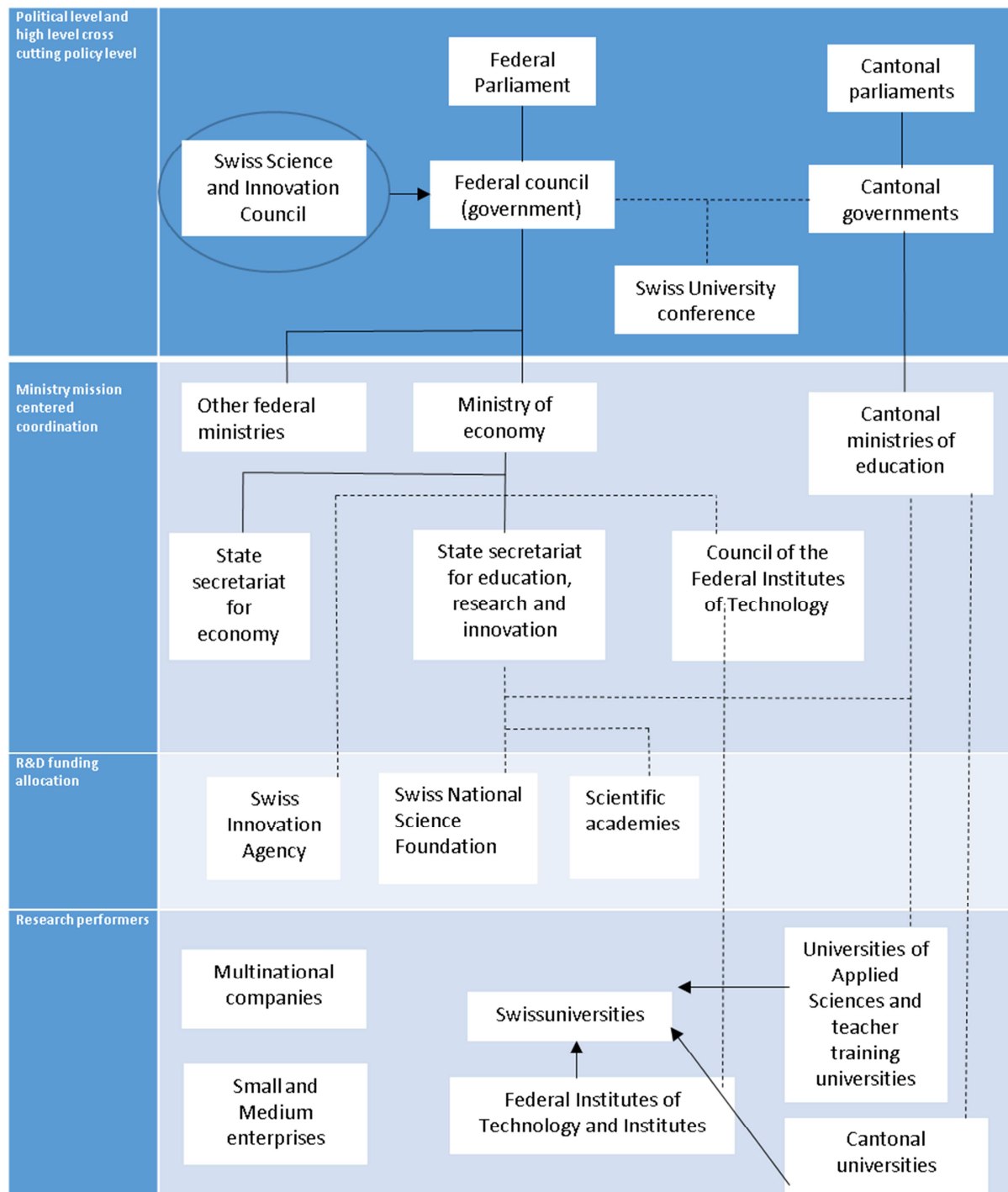


Figure 1. Organogram of the Swiss R&I policy

Policy coordination. Policy coordination represents a particularly complex issue in a decentralized system, where competences are shared between the Confederation and the cantons. Historically, decision-making processes in Swiss R&I policy have been rather fragmented between the federal level and the cantonal level and between basic science and innovation-related R&D.

However, since the late 90s, decisive steps have been made to reinforce the policy coordination at the national level, both at the institutional, strategic and budgetary level.

a) The federal decision-making structures have been consolidated by concentrating all competences for R&I policy in the Economy department since 2013, and attributed a central role in the coordination of the national R&I policy to the SERI, whose realm of competences now covers the entire higher education sector (with the partial exclusion of the FIT domain), basic research, applied research and vocational education and training.

Since the Swiss government has only seven ministries, each of them comprises several policy tasks under the same Federal Councillor and State secretariats or federal offices are usually the units that deal with individual portfolios within ministries. Therefore, the SERI has by large become the equivalent of a R&I ministry in other countries.

b) Policy coordination of the higher education system, which represents the core of public research, has been reinforced in a decisive way with the adoption in 2015 of the new higher education funding and coordination act (HEDA), which provides a general framework for the joint governance of the system between Confederation and cantons.

The Swiss Conference of Higher Education Institutions ensures policy coordination, a joint political body where Confederation and cantons are represented at the ministerial level, which replaced the Swiss University Conference in 2015. The Conference is responsible for the coordination of the entire system, for defining the mission of the different types of HEIs, for defining rules for HEI funding and for the regulation of the admission and organization of studies. The operational coordination and strategic planning between the HEI has been delegated to Swissuniversities, a joint association of universities, Universities of Applied Sciences and Universities of Teacher Education, which replaces the three former rector conferences.

c) Policy coordination is by large implemented in the *national R&I strategy*, which is decided by the Swiss parliament every four years and constitutes the basis for the four-year budgetary plans of the Confederation in the R&I domain. A broad process of consultation backs the preparation of the strategy between the involved parties, including the cantons, the higher education institutions, the national funding agencies and representatives of the economy – particularly the Association of Swiss Economy, Economiesuisse. Since the strategy is directly connected with the four-year R&I budget, it leads to a very high level of predictability for public R&I spending from the federal state and, therefore, to a very stable financial environment for public-sector research.

The national R&I strategy is presented in more detail in section 2.1 of this report.

Evaluation and quality assurance. The evaluation and quality assurance system is largely based on subsidiarity: it is first and foremost the duty of the performing organizations themselves, particularly of higher education institutions, to regularly evaluate the quality of their research activities and to take measures in order to keep it.

Nevertheless, a number of bodies and instruments have been established at the national level for evaluation purposes. The Swiss Accreditation Council and the Swiss Agency of Accreditation and Quality Assurance in Higher Education, which are attached to the Swiss Conference of Higher Education Institutions, are responsible for accreditation of HEIs and their curricula, as well as for periodically evaluating the internal quality assurance system of HEIs.

The Swiss Science and Innovation Council is responsible for the evaluation of Swiss R&I and, particularly, for evaluating the quality of public-sector research organizations funded by the Confederation.

The SERI regularly undertakes evaluations of agencies and programs at the national level; in recent years, evaluations have been undertaken for both national funding agencies (SNF, CTI), on the participation in EU-FP and the quality of the national support service Euresearch, on the International cooperation programs with third countries and on a number of national programs. Such evaluations are usually fed into the national R&I

strategy, where decisions concerning policy and organizational changes are proposed to the Swiss parliament. To our knowledge, no systematic evaluations of the overall economic impact of R&I are undertaken and implemented into the policy decision process.

1.2.3 Performers

Public sector. The public R&D system of Switzerland is by large dominated by higher education: with 0.83% of GDP, R&D expenditures in the higher education sector were almost double the EU-28 average in 2012, whereas expenditures in the government sector were marginal (0.02% of GDP against 0.25% for EU-28).

Since the mid-90s, Swiss higher education has had a binary structure, i.e. it comprises two distinct sectors (Universities and Universities of Applied Sciences) with distinct missions, organizations and funding rules (Lepori, Huisman and Seeber 2013).

The university sector comprises 10 cantonal Universities – seven generalist and three specialized – as well as the two Federal Institutes of Technology in Zurich and in Lausanne; the latter are mostly specialized in sciences and engineering, but have the same status and similar organization as cantonal universities. All universities offer bachelor and master degrees, as well as the PhD. Swiss universities are strongly research-oriented and some are among the leading international research universities – four Swiss universities were among the top-100 institutions in the 2015 Shanghai ranking, with ETH Zurich being the fourth European university after Cambridge, Oxford and UCL.

Universities of Applied Sciences (UASs) were created in the late 90s in order to strengthen professional education at the tertiary level and to support SME's innovative activities; they offer bachelor degrees with a strong professional orientation, as well as master degrees in selected domains, but cannot deliver PhD degrees. UASs also perform a substantial amount of applied R&D, largely in cooperation with SMEs, and are strongly engaged in technology transfer and continuing education. Additionally, Universities of Teacher Education (UTE) also belong to the UAS sector (some being integrated as UASs, some as independent schools).

The binary structure of Swiss higher education is generally considered a strength of the Swiss R&I system (Lepori and Müller 2016). It corresponds to the dual system of education, where pupils are already divided at the upper secondary level between a general education track and a vocational education track, based largely on apprenticeship and combining formal education and learning at work (SKBF/CSRE 2014). It allows for a clear differentiation of educational profiles, as well as of research profiles in higher education, with universities focusing more on basic research and international publication, and UASs on applied research and cooperation with SMEs.

Additionally, the higher education sector also includes four research institutes which are affiliated with the FIT domain: the Paul Scherrer Institute is a multi-disciplinary research centre for science and technology, which also provides some central facilities for university research; the three other institutes are more applied and oriented towards services in the field of material testing (EMPA), aquatic science and technology (EAWAG) and forests, snow and avalanches (WSL). The public research sector also includes some federal agricultural research institutes (AGROSWISS), as well as about 20 research institutes and infrastructures supported by the Confederation and mostly run by foundations. The federal administration also directly performs part of its R&D activities within ministries, but the volume of activities has strongly decreased in recent years.

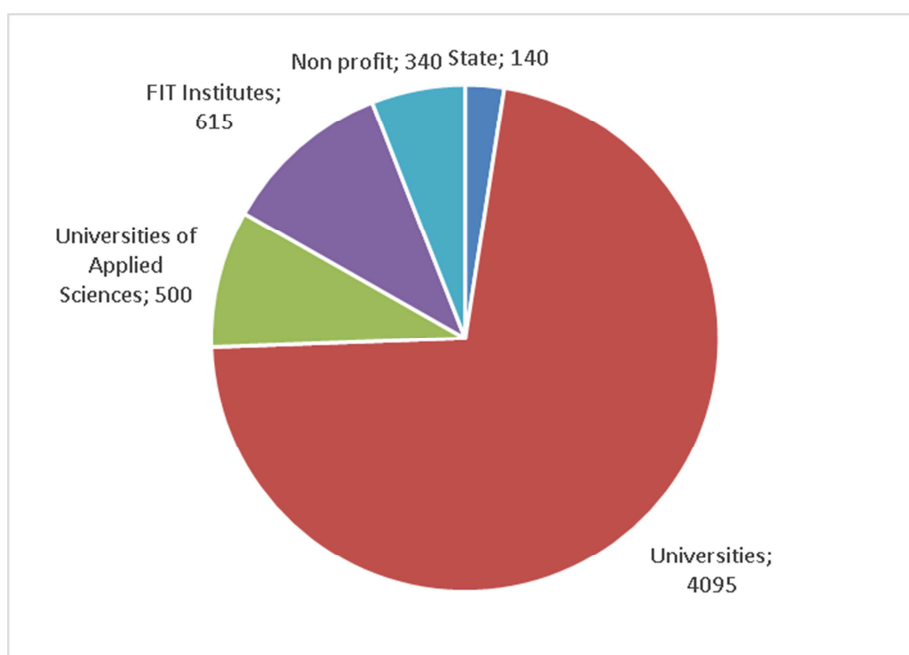


Figure 2. R&D expenditures of the public sector, 2012 (m CHF). Source: Swiss Federal Statistical Office (SFSO)

The *private sector* represents the core of Swiss R&I, accounting for 70% of domestic R&D expenditures; it is dominated by a small number of research-intensive multinational companies in sectors like food, pharmaceutical and mechanical engineering, but also by the presence of a highly-competitive environment of small and medium enterprises with strong innovative capacities (see Figure 3). According to a recent study, about 70% of the BERD in Switzerland is performed by multinational companies (Gassmann, Homann and Palmié 2016). Private R&D and innovation is almost exclusively funded by the companies themselves, the share of public funding being less than 1% of total R&D expenditures (Bundesamt für Statistik 2014).

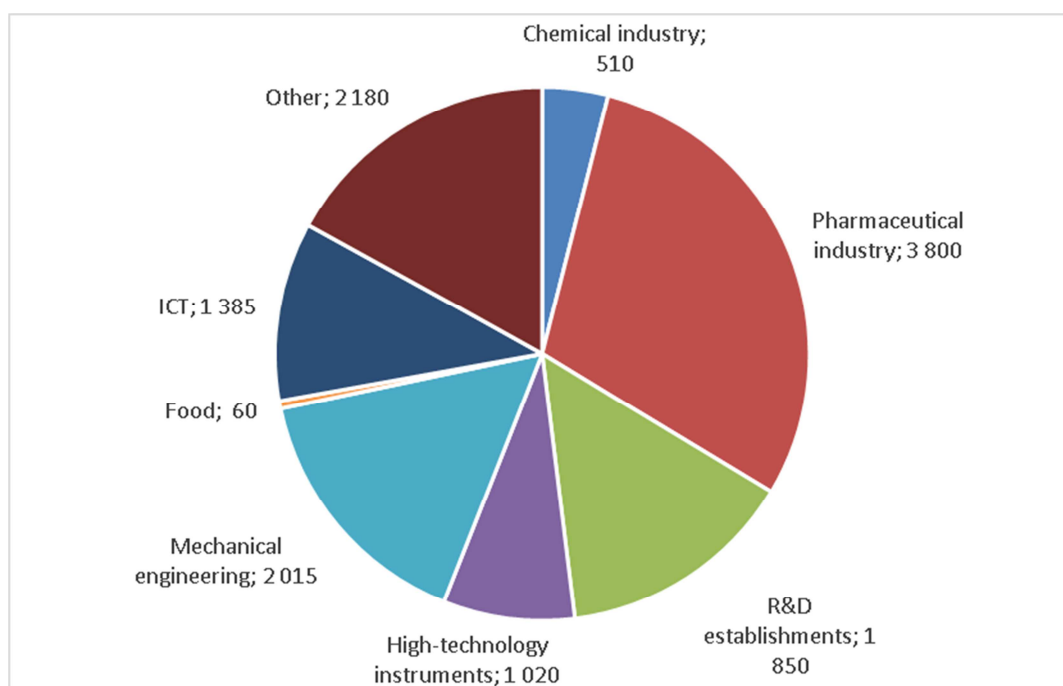


Figure 3. R&D domestic expenditures of the private sector, 2012 (m CHF) Source: SFSO

The level of domestic private sector R&D expenditures increased progressively from 1.67% of the GDP in 1992 to the current 2.05%, which is one of the highest spending levels in OECD countries after Finland, Japan and Israel. The importance of Swiss multinational companies is also reflected in the high level of R&D expenditures abroad, which amounted in 2012 to about 15 bn CHF, against 12 bn of domestic expenditures for Swiss private R&D (no specific data are available for individual companies, but multinational companies account for most of these amounts²).

R&D abroad of Swiss multi-national companies grows more rapidly than domestic expenditures, largely as an outcome of their international expansion and presence. At the same time, it remains that more than 40% of their R&D is performed in Switzerland and, therefore, delocalization of R&D activities occurred to a rather limited extent, when taken into account the size of the country. It is generally considered that the excellent quality of the local infrastructure and the presence of a strong public research sector account for this.

² Statistical data for this report are mostly derived from the Swiss Federal Statistical Office. Updated data are available at <http://www.bfs.admin.ch/bfs/portal/de/index/themen/15/09.html>.

2. Recent developments in Research and Innovation policy and systems

2.1 National R&I Strategy

Since the late 90s, the Swiss federal government has adopted a national strategy for the R&I system every four years, which is then transmitted to the federal parliament together with the request for budgetary credits for the following four years and, in most cases, also a number of changes of relevant laws and organizational structures. This plan, which is known as the Education, Research and Innovation (ERI) dispatch covers the entire tertiary education domain (both higher education and vocational education and training), direct research funding through projects and programs, cooperation with cantons in general education and international research cooperation. The Swiss R&I policy therefore reaches a high level of integration between policy domains; the only specific R&I measures which are not directly included in the ERI dispatch are direct support for economic innovation and regional economic promotion, which are the responsibility of the State Secretariat for the Economy.

The plan provides a systematic analysis of the state of the Swiss R&I system, based on statistical data and evaluation results, and identifies strengths and weaknesses, as well as emerging challenges. Further, it defines the strategic priorities for the R&I system, as well as the specific measures for each domain and actor. Finally, the plan includes the whole federal R&I budget for the following four-year period with a fine-grained division of resources by agency and funding streams.

The plan is prepared by the SERI based on an extensive consultation of all R&I actors and it is closely coordinated with the overall strategic and budgetary planning of the central State, which defines the amount of resources available for the R&I system in the following years. The plan also includes specific measures for the support of research infrastructures (see section 4.2.2).

The plan is approved by the federal government and discussed by the Swiss parliament, which eventually decides on the allocation of financial means for the following four-year period. This close link between the strategic plan and budgetary allocation is central to the current R&I policy process and translates into a very high level of stability and predictability for the public resources available – budgetary decisions can in principle be modified within the yearly budgets, but changes are usually quite limited. This also draws on the rather pragmatic stance of the ERI dispatch: while some strategic directions are defined, most of the plan is concerned with their implementation and the ensuing allocation of financial resources.

The current ERI strategic plan was adopted by the parliament in 2012 and covers the 2013 to 2017 funding period, for a total budgetary credits volume of 26 bn CHF, with a yearly increase of 3.7% from the 2008 to 2012 period (Schweiz. Bundesrat, 2012). The plan foresees three strategic priorities³:

- For *education*, to satisfy the demand for workers with general education or vocational education qualifications. This includes the reinforcement of Vocational Education and Training, ensuring the quality and international reputation of the Swiss higher education sector, particularly by creating adequate professor-student ratios, improving the learning capabilities and employability of young people by ensuring that at least 95% obtain upper-secondary level qualifications and coordinating the introduction of the new Federal Act on Funding and Coordination of the Higher Education Sector.
- For *research and innovation* to consolidate the high level of grant funding awarded on a competitive basis and further strengthen Switzerland's internationally

³ Source: http://www.sbf.admin.ch/org/01645/index.html?lang=en#sprungmarke3_23 (last consulted 05.10.2015).

competitive position. This includes positioning Switzerland's international reputation as a competitive location for research and economic activities by increasing the amount of grant funding awarded on a competitive basis for research and innovation, ensuring that Switzerland holds a top position in promising fields through targeted measures to improve research, development and innovation capabilities, and maintaining the strategic importance of international cooperation and networking with European and non-European countries.

- For the *general aspects of the Swiss R&I system*, to establish Switzerland as a location where research and economic activities are based on the principles of equal opportunity, sustainability and competitiveness. This includes strengthening social cohesion through the production, dissemination and use of knowledge, allocating greater funding to train the next generation of researchers and qualified workers, promoting equal opportunities and sustainable development by serving social, economic and environmental interests.

The new strategy for the period 2017-2020 was published in February 2016 (Schweiz. Bundesrat 2016). Its main directions are continuity with the past, given the fact that the Swiss R&I works quite well, as well as targeted development in a few priority areas (by also taking into account financial constraints):

- The reform of tertiary vocational education and the improvement of its funding.
- Ad hoc measures for the promotion of scientific careers.
- Specific measures for human medicine to increase the number of trained surgeons.
- Structuring and long-term measures to promote innovation.

Table 2 presents the volume of requested budgetary credits for the period 2008 to 2016.

Table 2. Budgetary credits for the R&I system at the federal level, 2008-2020 (m CHF). Source: dispatch 2013-2016. 2012 is shown separately as it had a separate budget.

	2008-2011	2012	2013-2016	Growth 2008-2016
Professional education	2,664	878	3,600	6.4%
FIT domain	8,258	2,174	9,481	3.5%
Cantonal universities	2,652	701	3,017	3.5%
Universities of Applied Sciences	1,628	467	2,106	6.8%
Swiss National Science Foundation	2,816	851	3,720	8.9%
Swiss Innovation Agency	480	132	547	4.8%
Science and society	115	28	120	2.5%
Public research institutions	212	60	296	4.3%
Students' grants	99	25	103	-11.0%
International cooperation	233	66	232	8.7%
European Space Agency	479	125	528	3.2%
EU education programs	86	32	149	11.0%
EU research programs	1,245	458	2,181	9.1%
Total	20,967	5,997	26,080	5.1%

These data show that budgetary credits for R&I have grown at a sustained rate in the last decade, more rapidly than general expenditures of the Confederation (see also section 3.2) and that the budgetary policy in this domain is characterized by a high level of continuity in the repartition of funding between different streams (see also section 3.3).

2.2 R&I policy initiatives

Following the main orientation of Swiss R&I to define framework conditions for the activities of the research organizations, most policy initiatives in recent years dealt with the governance and organizational structure of the system, rather than with the definition of specific thematic priorities in research. Such reforms have substantially

reshaped the overall governance of R&I in Switzerland. The new measures proposed and included in the strategic plan 2017-2020 are covered at the end of this section.

Policy governance reforms

a) *Higher Education Coordination and Funding Act (HEDA)*. The new act, which entered into force at the beginning of 2015, represents a fundamental step towards a coordinated policy governance of the entire higher education sector, partially overcoming the previous fragmentation between domains (universities, FITs, UASs) and between the Confederation and cantons. It is grounded in the principle that higher education is a joint competence of the Confederation and cantons, which since 2006 is inscribed in the federal constitution. The act establishes general principles for the governance, steering and funding of higher education and reinforces the existing policy governance structures. It builds on the notion that there are distinct types of higher education institutions – universities, Universities of Applied Sciences, Universities of Education – with distinct missions and, therefore, partially different rules, but which are part of a single national higher education system (Schweiz. Bundesrat, 2009).

b) *Reorganization of the federal administration in the R&I domain*. Historically, the competences in the federal administration for the R&I domain were divided between the Department of Internal Affairs (universities, basic research) and the Department of Economy (Universities of Applied Sciences, Vocational Education and Training, Applied Research), since the organization of the Swiss government made the creation of a R&I ministry impossible. This divide weakened the policy coordination and visibility of the R&I sector. Since 01/01/2013, all competences have been moved to the Economy Department by creating the State Secretariat for Education and Research. This reorganization substantially strengthened the political governance of the whole system and fostered more coordination between basic science and innovation-oriented activities.

c) The total revision of the *Swiss Research and Innovation Act* was submitted by the Federal Council to the Swiss parliament at the end of 2011, and was approved by the parliament in December 2012 and was adopted in January 2014 (Schweiz. Bundesrat, 2011). The revision was a rather incremental step, with the aim of making the legal basis of the Swiss R&I policy more systematic and consistent and to coordinate with the new university act (HEDA). The tasks of the two funding agencies (SNF and CTI) have been made more precise in order to clarify their complementarity, while the legal basis for international research policy has been clarified and the legal basis for the creation of the Swiss Innovation Park has been introduced (see further below).

d) *Reform of the Swiss Innovation Agency*. The Swiss Innovation Agency (CTI) was founded in 1944 as an independent expert commission to provide support to research of economic interests. As such, it has historically enjoyed a more limited autonomy from the State than the Swiss National Science Foundation, which is legally a private foundation. CTI was closely tied to the Economic department and all final funding decisions had to be taken by the political authorities. The rapid expansion of funding volume and the tasks of CTI since the 90s has required a reinforcement of its organizational structure and independence; after a number of organizational measures in the recent years, the Federal Council finally decided at the beginning of 2015 to transform CTI into an independent public institution, with an organization similar to the SNF. This reform is meant to reinforce the role of CTI in the Swiss R&I system thanks to a clearer distinction between policy and funding decisions, more flexibility and

independence. The proposal for reform was submitted to the parliament by the Federal Council in November 2015 and is expected to be approved by 2016.

e) *Creation of the Swiss Innovation Park.* The Swiss Innovation Park is supposed to offer excellent location opportunities for innovative companies in Switzerland, as well as support services in R&I. The legal basis was created in 2012 with the revision of the Research and Innovation Act, while the federal government in 2014 approved the configuration based on legal hubs, with the Swiss Innovation Park Foundation being created in 2015 (see further section 5.6 for a more detailed description).

Program initiatives and support measures

While the core of Swiss R&I policy is based on continuity, a number of specific support measures have been launched during the last five years in order to address specific policy issues. Further, a whole set of new measures is foreseen with the 2017-2020 ERI Dispatch.

Swiss Franc. In order to help the economy to overcome the effects of the strong escalation of the Swiss Franc towards the euro in 2011, the Federal Council decided on a set of special measures to support R&D in companies. To this aim, additional funding was provided to the Swiss Innovation Agency CTI to support cooperative projects between academia and companies; a total of more than 350 projects for a funding volume of 140 m CHF were supported in the short period between fall 2011 and spring 2012. No similar measures were discussed in 2015, when the Swiss National Bank abandoned the threshold of 1.2 CHF per euro, as it was considered that the economy had sufficient time to adapt.

Energy research plan. In 2011, the Swiss parliament decided the stepwise exit of Switzerland from nuclear energy. The existing nuclear plants, which produced about one-third of the country's electricity in 2013, should continue operating until the end of their technical life, but will not be replaced and, therefore, nuclear energy will no longer be available from 2030 onwards. To cope with this situation, an ambitious plan for improving energy efficiency and promoting renewable energy has been launched (the so-called Swiss energy strategy 2050). To this aim, a whole set of measures has been launched to support energy research, with a focus on efficiency and renewable energy sources; these include (Schweiz. Bundesrat, 2012a):

The creation of energy competency centres in the FIT domain (60 m CHF for the years 2013-2016).

The support by the CTI of energy competency centres in the universities and UAS sector, and additional financial means for cooperative projects (118 m CHF).

Measures to support researchers in the energy field through personnel grants and on the post-doctoral and assistant professor level managed by the Swiss National Science Foundation (24 m).

New measures in the strategic plan 2017-2020

The 2017-2020 strategic plan forecasts priority domains where new initiatives will be launched.

a) Reform and improvement of the financial conditions of tertiary vocational education. Professional education at the tertiary level is a core component of the Swiss education system and is considered to be a strength of the country: the current decentralized system, mostly organized by professional associations, responds quite well to the needs of the economy. To broaden access to vocational education, the Confederation will strongly increase subsidies for the preparation of courses for professional exams from 2017 to 2020, in order to reduce the tuition fees paid by students (which now represents the main source of financing within the system).

b) Promotion of scientific careers. The promotion of scientific careers is a central concern for the Swiss R&I system, which increasingly relies on foreign professors and researchers. The increasing number of temporary positions at the post-doctoral level and the lack of structured career opportunities represent a specific concern in the Swiss system. To improve this situation, the creation of 160 additional tenure-track positions for young researchers in Swiss universities has been proposed; the Swiss National Science Foundation will also provide additional research opportunities to young assistant professors (APTT grants). Finally, the current program to support doctoral education by Swiss universities will be continued and extended.

c) Education in clinical medicine. Switzerland suffers from a shortage of trained surgeons: the limitation in the number of study places in universities and the high turnover in this profession lead to a shortage and the need to rely on surgeons trained abroad. In the period 2017-2020, the Confederation will support universities in their extension of educational programs in clinical medicine with the goal of increasing the number of graduates from 900 to 1300 surgeons per year. Among the planned initiatives, a bachelor program in medicine at ETH Zurich and master studies at the Università della Svizzera italiana, in Fribourg and St. Gallen are proposed.

d) Innovation support. While innovation is mostly driven by the private economy, the strategy for 2017-2020 foresees a number of measures to reinforce the cooperation between the public and private sector, including: the reinforcement of the role of technology centres and the creation of a Swiss innovation park (see section 5.6); the reform of the Swiss innovation agency (see section 2.2); the launch of a new program for pre-competitive research at the Swiss National Science Foundation (program "Bridge", in cooperation with the Swiss innovation agency) and a new series of national centres for competence in research, which also includes relevant domains for innovation.

2.2.1 Evaluations, consultations, foresight exercises

The Swiss R&I policy is characterized by a high-level of cooperation and broad consultation of stakeholders and citizens in the preparation of the political decisions. These processes are institutionalized, as all major policy reforms have to go through a process of consultation where the involved stakeholders are requested to provide their feedback on policy proposals. Such a process is important within the Swiss direct democracy, since, by collecting 50,000 signatures of voters, it is possible to request a referendum on all laws decided by the parliament (except on budgetary decisions).

The Swiss R&I strategy is also the object of an extensive stakeholders' consultation, which is governed by the research and innovation act; in the preparation phase of the strategy, all relevant R&I actors are requested to prepare their medium-term planning and formulate requests for budgetary credits. For example, both SNF and CTI already published in early 2014 their (proposed) planning for the period 2017-2020. A similar process concerned the Swiss Research Infrastructures strategy, where a bottom-up process based on submission and evaluation of proposals was established (see section 4.2.2).

In R&I evaluation, an important role is played by the Swiss Science and Innovation Council, which by the Research and Innovation Act, is officially responsible for periodically evaluating the Swiss R&I policy. Recent SSIC activities in this context include: statements on all major policy proposals, including energy research policy, the reform of CTI, the new funding model and organizational structures in higher education; the evaluation of a number of instruments managed by the SNF; the evaluation of the research institutes funded directly by the Confederation.

A large number of evaluations is also contracted directly from the SERI, deriving from its general competence for evaluating all of the Confederation's support measures. This included the evaluation of the Swiss National Science Foundation (2013), of the Swiss Innovation Agency (2002), of the bilateral cooperation programmes with emerging countries (2010), of Federal Innovation support measures (2013) and the Swiss

participation in EU-FP (2014). SNF also recently evaluated its project evaluation procedures, its funding instruments and measures to support researchers' careers.

Evaluation of quality of research within higher education institutions is mostly the responsibility of the HEIs themselves; the Swiss Agency of Accreditation and Quality Assurance, an independent agency under the Swiss Accreditation Council, assumes a complementary role by regularly assessing the HEI internal quality assurance processes and by evaluating requests for accreditation of new higher education institutions.

Finally, the SERI has published at the beginning of 2016 an extensive report on research and innovation in Switzerland (SBFI, 2016). The report provides a systematic overview of the Swiss R&I system, a set of core indicators on research and innovation performance, and includes four in-depth studies on key topics, i.e. R&D of small and medium enterprises, R&D of multinational companies, the public measures for innovation support and, finally, the contribution of Universities of Applied Sciences to the Swiss R&I system. The report is available on-line in French and German, an English version is planned (<http://www.sbf.admin.ch/themen/01367/02847/index.html?lang=de>).

2.3 European Semester 2014 and 2015

Not relevant for Switzerland as Switzerland is not an EU Member State.

2.4 National and Regional and Innovation Strategies on Smart Specialisation

With regards to Innovation Strategies on Smart Specialization (RIS3), Switzerland has not developed a proper strategy. Nevertheless, the current regional economic policy (2008-2015) features most of the aspects that characterize RIS3s (SECO, ARE, 2013).

The three components of the Swiss New Regional Policy (NRP), which can be assimilated to RIS3s are the following (SECO, 2008):

- To consolidate regional economies by boosting innovation, reinforcing competitiveness and promoting structural change of regional economies (pillar 1). Pillar 1 will mostly be implemented by the cantons with a coordinating function of the Confederation and in close cooperation with the private economy.
- To coordinate regional policies with federal policies in the relevant policy domains like innovation support, tourism, land planning, research and educational policies (pillar 2). Pillar 2 will mostly be implemented by the Confederation.
- To develop the processes needed to implement regional policies and empower stakeholders (pillar 3). Pillar 3 will mostly be implemented by the Confederation.

The NRP aims to boost economic promotion and innovation at the regional and cantonal levels. However, there exists an intrinsic contradiction within the NRP. Basically the NRP asks for cantonal development plans as well as for inter-cantonal co-operation (OECD, 2011, p. 135). Regiosuisse, in reviewing the first eight years of the NRP (2008-2015), considers that the implementation of this policy has been defined by a natural learning curve where successful experiences are alternated with failures. One of the latest is the generation of inter-cantonal competition (Regiosuisse, 2015, p.9).

In addition, inter-cantonal initiatives should appear under one cantonal plan and therefore stick to the promoting canton instead of sharing responsibilities with the potential partner. Beyond that, the NRP funding allocation system may also generate competition among cantons since those funds are going to be likely adjudicated to those cantons presenting the best plans. Nevertheless, once joint interests are identified inter-cantonal co-operation is highly possible and the results are satisfactory. The health and education sectors are some examples of this successful co-operation. In line with this, Regional Innovation Strategies (RIS) projects, when deployed under appropriate conditions, may facilitate inter-cantonal innovation promotion activities (OECD, 2011, p. 135).

As a country sharing borders with economies such as Italy, France, Liechtenstein, Germany and Austria, Switzerland has a great potential for international cross-border co-operation and innovation. In this regard the NRP also promotes and encourages this type of international co-operation. The EU funded INTERREG, INTERACT, URBACT and SPON programmes are examples of this cross-border co-operation. The Federal Office for Spatial Development (ARE) implements the transnational Interreg programmes (Interreg B), URBACT, ESPON and the macro-regional strategy EUSALP (Regiosuisse, 2015).

2.5 Main policy changes in the last five (5) years

Provide the summary table indicating the timeline of the recent policy changes.

Main Changes in 2011
ERI dispatch 2011 (transitional year)
Special support measures to compensate for the strength of the Swiss Franc
Main changes in 2012
ERI dispatch 2013-2015
Support measures for energy research launched.
Main changes in 2013
Reorganization of the federal administration: all R&I competences in the Economy department.
Main Changes in 2014
Revision of the Federal Research and Innovation Act.
Agreement for a partial association of Switzerland in the Horizon2020 (after exclusion from the association due to the immigration initiative).
Main Changes in 2015
Adoption of the new higher education coordination and funding act.
Proposal for a new act on the Swiss Innovation Agency.
Proposal for a Swiss Innovation Park
Swiss Roadmap for Research Infrastructures.
Proposal for a revision of Vocational Education and Training.

3. Public and private funding of R&I and expenditure

3.1 Introduction

As shown by Table 3, Switzerland is characterized by a very high level of R&D spending both in the public and in the private sector. R&D funding from the private sector is traditionally among the highest in OECD countries and stayed quite stable as a percentage of GDP since 2000 (therefore strongly increasing in terms of absolute amounts of spending). Despite an increase in R&D expenditures abroad from multinational companies, there are no signs of a relocation of R&D activities. GERD per capita is almost four times the EU-28 average.

Government R&D funding was traditionally aligned with the EU-28 average in the past, but substantially increased since the year 2000 as an outcome of R&I funding being assigned a higher priority in the State budget (see below section 3.2); this level is particularly remarkable as almost all public funding is devoted to public-sector research.

Both the shares of funding flows and of performing sectors have been remarkably stable over the last two decades, displaying the high level of stability and continuity of the Swiss R&I system. The increase in funding from abroad is due to two factors: increasing international flows in the private sector and the growing importance of European research programmes (see section 3.3.2).

Table 3 Basic indicators for R&D investment

R&D data for Switzerland are available only every four years.

Indicator	1992	1996	2000	2004	2008	2012	EU average (2015)
GERD (as % of GDP)	2.38	2.45	2.33	2.66	2.73	2.96	2.01
GERD (Euro per capita)	731	902	956	1,152	1,352	1,931	536
GBARD (€m)	1,568	1,856	1,733	2,189	2,621	4,518	92,094
R&D funded by BES (% of GDP)	1.60	1.65	1.61	1.85	1.86	1.80	1.10
R&D funded by GOV (% of GDP)	0.68	0.66	0.54	0.60	0.62	0.75	0.66
R&D funded by other (% of GDP)	0.05	0.06	0.08	0.06	0.08	0.05	0.03
R&D funded from abroad	0.04	0.08	0.10	0.14	0.16	0.36	0.19
R&D performed by HES (% of GERD)	25.00	24.30	22.90	22.90	24.20	28.10	23.38
R&D performed by government sector (% of GERD)	3.70	2.50	1.30	1.10	0.70	0.80	12.44
R&D performed by business sector (% of GERD)	70.10	70.70	73.90	73.70	73.50	69.30	63.68
R&D performed by PNP (% of GERD)	1.20	2.50	1.90	2.30	1.60	1.80	1.00

3.2 Smart fiscal consolidation

Switzerland is traditionally characterized by a very stable and healthy situation concerning their public finances. The share of the State expenditure in the national economy increased only modestly over the last two decades and remains well below most EU States. Public finances are also characterized by a very low level of deficit and of State debt: while the 90s were characterized by rather high deficits (total deficit of the State sector reaching 3% in 1993), since 2000 the situation has improved and State accounts (Confederation, cantons and municipalities) closed with a positive result in 9 out of the 14 years since 2000. The total debt of the State sector was around 30% of the GDP in 1990, increased to 50% in 2000, but dropped below 35% thereafter thanks to a series of positive results and economic growth.

This budgetary context had favourable implications for the R&I sector. On the one hand, public spending enjoyed a modest, but quite stable growth in the last two decades, with growth rates around 2%. On the other hand, R&I expenditures have been considered a priority and thus constantly grew at a higher rate than average spending.

The average yearly growth of R&I expenditures at the federal level was 5.9% for the period 2007-2011 (against 3.6% for the total expenditures at the federal level), 3.8% for the years 2011-2015 (2.4%), while the planned increase for the period 2014-2018

is 3.8% against 2.4% for the total. As a result, the share of the R&I domain in the total expenditures of the federal state increased from around 8% in the 90s to more than 11% (see Figure 4).

The perspectives for the next years however are less favourable. In winter 2015, the Swiss Confederation issued a stabilization plan of finances, which follows the decrease of fiscal revenues due to the economic slow-down. The plan foresees substantial cutbacks among resources devoted to research, higher education and innovation. Nevertheless, a nominal 2% p.a. increase in total federal funding for the whole sector is still planned for the years 2017-2020.

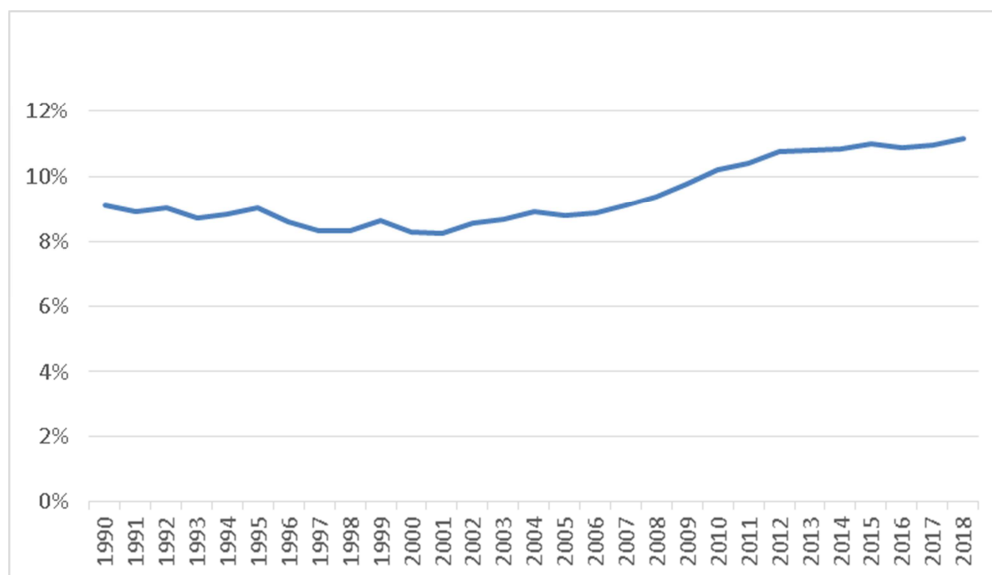


Figure 4. Expenditures for research and higher education as a % of total expenditures from the federal state. Source: federal administration of finances.

3.3 Funding flows

3.3.1 Research funders

Following bodies are in charge of allocating most of public funding. A detailed overview of public funding flows is provided in section 3.3.2.

a) The *State Secretariat for Education and Research* (SERI) manages a large share of the federal funding to public R&D, including the following streams:

- Federal institutional funding to cantonal universities and Universities of Applied Sciences (see section 3.4.2). This stream also includes the funding of strategic cooperation projects between higher education institutions based on a decision from the Swiss University Conference.
- Swiss contributions to international research performers (CERN) and to international funding agencies (European Space Agency), as well as the Swiss contribution to European Framework programs, corresponding to national co-funding for Swiss participation to Horizon 2020 projects (see section 3.4.3).
- Direct federal contributions to public and non-profit research institutes outside the university sector, subject to recognition by the federal government.
- Federal co-funding to Vocational Education and Training.

b) The *Council of the Federal Institutes of Technology* manages all federal funding to the FIT domain and is responsible for the repartition of the funds between the two schools

(ETH Zurich and EPF Lausanne), the four institutes of the FIT domain and the strategic programmes.

c) The *Swiss National Foundation* (SNF) is the most important national funding agency, with the mission of supporting knowledge-oriented basic research and the training of young researchers. It is a private foundation, whose task is defined by the national research act and is almost completely funded by the federal state. It however enjoys a large degree of autonomy from the State in its decision-making processes; committees composed by academics and based on external peer reviews of project applications adopt most of the SNF's funding decisions.

The SNF funding portfolio is composed by investigator-driven basic research projects (about two-thirds of the budget), personal grants for academic research careers and a number of cooperative programs (see below section 3.4.3).

d) The Commission for Technology and Innovation (CTI) is an independent expert commission within the Department of Economy that is de facto the national agency for the support of innovation. The Commission is composed by representatives from the academic sector, policy and private companies who fund cooperative projects between higher education institutions and private companies. The CTI also provides support to technology transfer activities and start-ups and finances a large training program in entrepreneurship (see in section 5.3).

The process of transforming the CTI into an autonomous public agency with a similar organization as the SNF is expected to take place in 2017 (see section 2.2). The name of the agency should also be changed to *Innosuisse*.

e) The *cantons* are involved in public R&I funding through institutional funding of the 10 cantonal universities and of the public Universities of Applied Sciences, which includes, alongside education, a research component.

f) Despite the dominance of the two national funding agencies (SNF and CTI), other federal ministries play some role in funding policy-relevant research in their specific domain. The role of ministerial programs constantly diminished in the last two decades, since there is a tendency to attribute the management of new policy initiatives like R&D for development cooperation to the SNF or CTI (SNF R4D programme) and energy research (joint SNF-CTI program). Research is partially undertaken internally in the ministries, partially through contracts with other R&D performers. The most important domains remain agricultural research (where the Confederation directly manages agricultural research units), defence (with however a very limited amount of funding when compared to other countries) and energy research (including substantial support for testing and experimental development).

g) The role of private non-profit funding is rather limited in Switzerland, as there are no large foundations providing substantial amounts of money. However, there is a number of private funding supporting research projects, particularly in the higher education sector. The domain is highly fragmented and there is a limited overview for these funding activities.

3.3.2 Funding sources and funding flows

Figure 5 provides an overview of the structure for the funding flows of the Swiss R&I system. Its main characteristic is the clear-cut division between the public and the private sector.

a) Private R&D activities are essentially auto-financed by the companies themselves, including an important component of private funding from abroad (and respectively of R&D expenditures abroad). Very little direct public funding to private R&D is available, but other indirect mechanisms exist, particularly through joint projects with public research funded by the CTI (see section 3.4.3).

Not providing public funding to private R&D is a lasting characteristic of Swiss research policy, which is also supported by associations of Swiss enterprises and by multi-national companies. It is generally considered that the function of the public sector is to support basic research and human capital training, from which private companies will also benefit. Moreover, R&D investments of multi-national companies are so large that public R&D funding from the Swiss State would play a limited role. Support for R&I in small and medium enterprises has been addressed through cooperative projects with the public sector and the establishment of the Universities of Applied Sciences.

Private funding of higher education research is substantial, exceeding 10% of total R&D expenditures in the higher education sector; it largely benefits the two Federal Institutes of Technology, but also Universities of Applied Sciences. It is mostly in the form of R&D contracts.

b) Public funding of R&D is essentially devoted to the higher education sector and divided between the Confederation and the cantons in proportions of two-thirds to one-third. Cantonal funding is composed almost completely by institutional funding to higher education, whereas federal funding is approximately divided in equal parts between institutional and project funding. Public funding abroad is mostly composed of contributions to international funding agencies (particularly European Space Agency), to international performers and a large contribution for participation in European Framework programs. Funding from abroad to higher education is composed mostly by contributions from the European Framework programs (see below section 3.4).

The payments to Swiss R&D performers from the EU-FP exceeded 300 m CHF in 2012 and reached about 2 bn euros for the entire EU-FP7, making Switzerland by far the largest non-EU recipient country of EU-FP7 (and the sixth country overall for the volume of funding). The situation profoundly changed since 2014 because of the only partial association in Horizon 2020 (see below section 4.2).

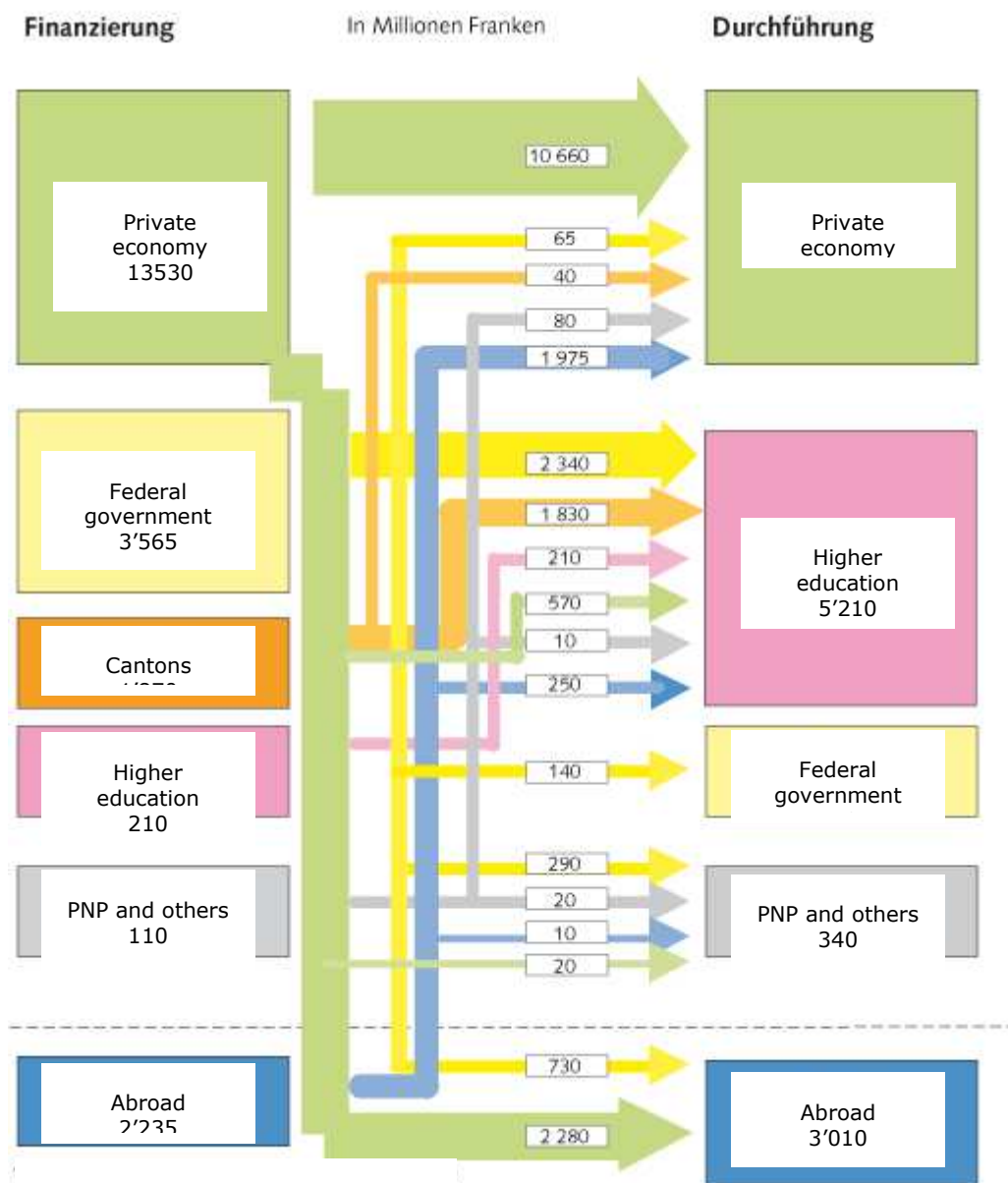


Figure 5. Funding flows for R&D in Switzerland. Source: SFSO

There are no reliable estimates concerning the share of Foreign Direct Investment which is related to R&D in Switzerland; an analysis based on economic sectors suggests however that most of the FDI is indeed concentrated in the economic sector and characterized by high R&D intensity; for a more detailed analysis of FDI, refer to section 5.5 of this report.

3.4 Public funding for public R&I

Figure 6 displays an overview of the main streams of public research funding for the year 2014. The repartition between project and institutional funds was about one-third to two-thirds and the main streams were federal institutional funding for the FIT domain, cantonal institutional funding for universities and transfer to the Swiss National Science Foundation.

This structure has been remarkably stable during the last two decades, except a slight increase in the share of project funding and a substantial increase in international contributions, particularly concerning EU-FPs.

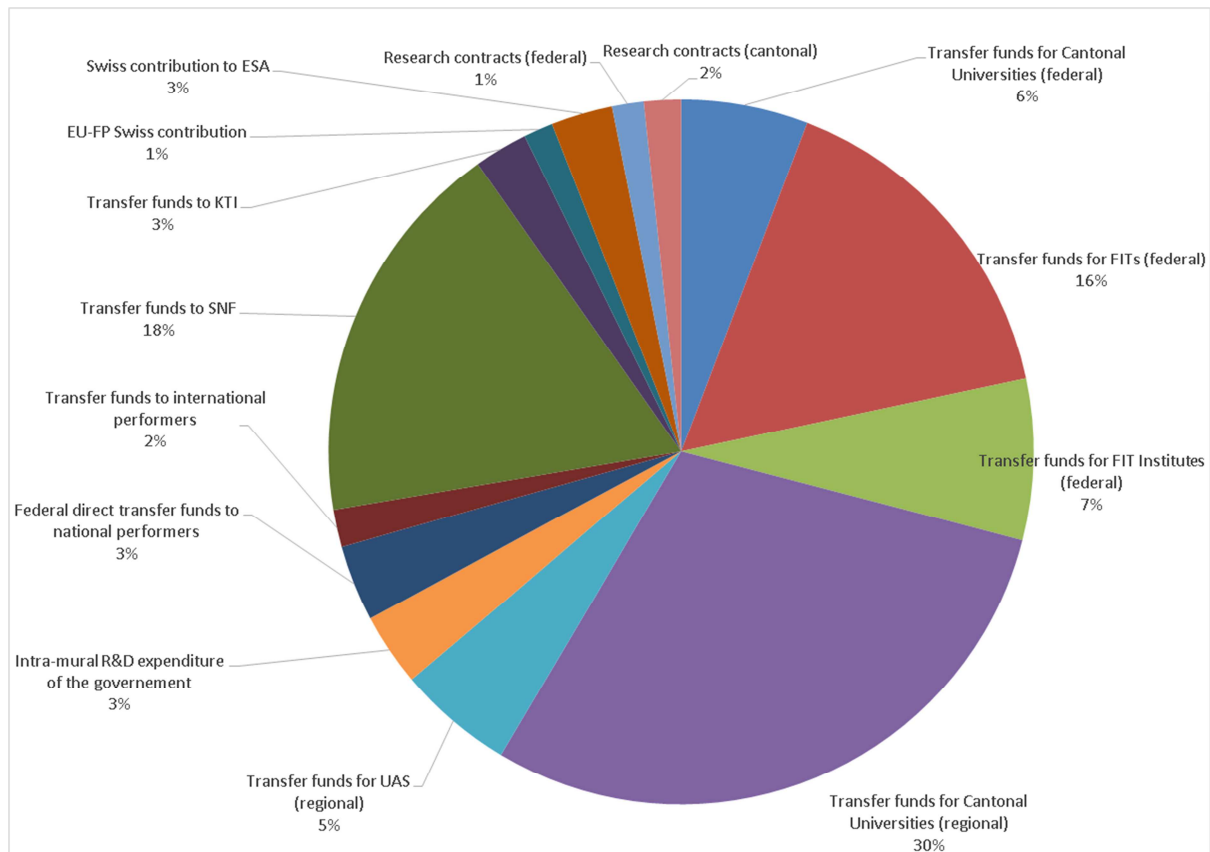


Figure 6. Structure of public R&D funding in Switzerland, 2014. Source: SFSO, elaboration for the PREF project.

3.4.1 Project vs institutional allocation of public funding

The share of project funds in the total GBAORD increased from 23% in the year 2000 to 33% in 2014 (last available year. Source: SFSO). This evolution was mostly due to two factors: first, the increase in funding attributed to national funding agencies – particularly to the SNF – which exceeded the general increase of public R&D funding, second, the rapid growth of the Swiss participation in EU Framework programs after the full association in EU-FP6 in 2004.

There is a clear institutional distinction between project funds and institutional funds, which are allocated by different bodies. Institutional funds at the federal level are managed by the SERI (cantonal universities, Universities of Applied Sciences) and by the ETH-RAT (Federal Institutes of Technology), as well as by the cantons for their universities. Project funds at the national level are managed by the two funding agencies (SNF and CTI), while the role of other ministries and funding bodies is rather limited. EU-FP has become a major source of project funds for Swiss research performers.

As discussed in detail below, institutional funding for R&D is not very competitive and there have been no significant changes in recent years. The Swiss system can therefore be broadly characterized by two complementary public R&D funding modes: institutional funding provides baseline resources for HEIs to undertake research, mostly in disciplinary contexts, whereas project funding provides additional resources for the best research groups, with a strong focus on academic research (Lepori 2011).

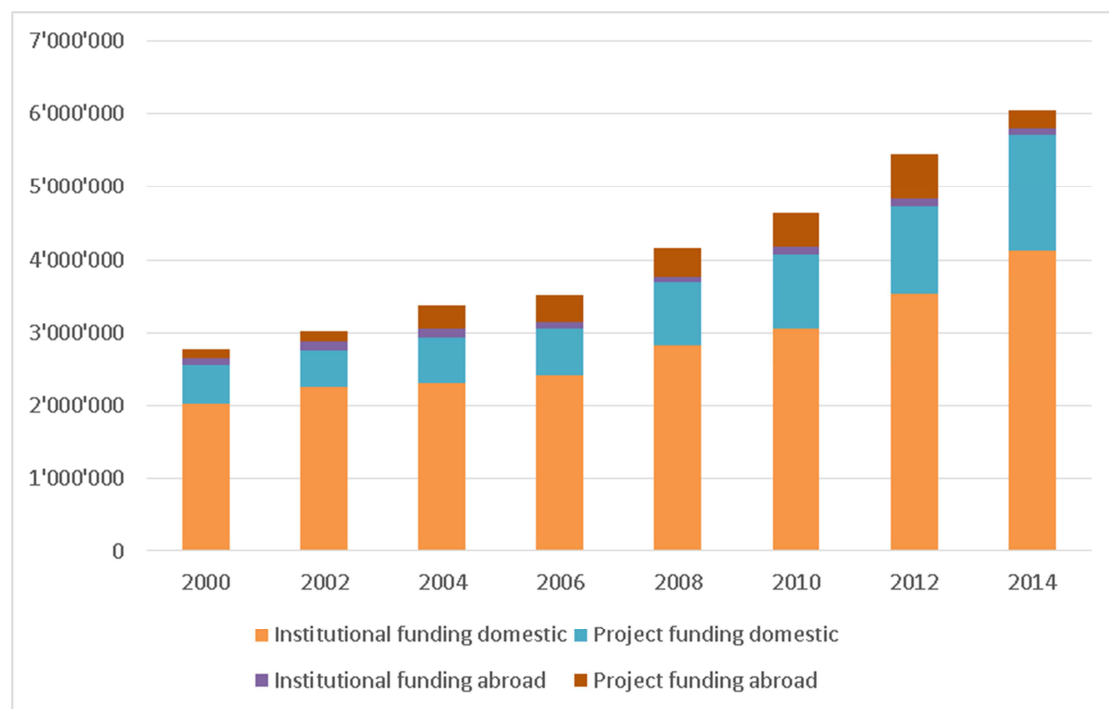


Figure 7. Public funding by funding mode 2000-2014 (m CHF). Source: SFSO.

3.4.2 Institutional funding

The organization of the Swiss higher education system leads to a differentiated pattern of funding by type of HEIs (FITs, cantonal universities, Universities of Applied Sciences). While competition is relatively limited, this structure is effective in differentiating the level of funding and funding conditions by type of HEIs. This approach is consistent with the new Higher Education Coordination and Funding Act, which explicitly states that levels of funding (and the relative balance between research and education) can differ depending on the HEI's mission.

It should be remarked that institutional funding of HEIs is in most cases jointly attributed to research and education, while the decision on the effective use of resources is left to the HEIs themselves.

a) *Federal Institutes of Technology*. FITs are funded by the Confederation through a block grant, which is linked to a performance contract between the Confederation and the ETH-RAT. This is a rather soft arrangement, without a formal link between performance and funding, but FITs are clearly expected to maintain their position among the best reputed international universities and are therefore subject to strong quality pressures.

b) *Cantonal universities*. cantonal universities are mostly funded by their home canton and co-financed by the Confederation. The cantonal core grant is usually negotiated directly between the canton and the university, a performance contract having been introduced in a number of cases. Overall, this grant has a strong historical component concerning R&D, whereas student numbers are important for educational allocation (co-funding by other cantons is based on a fixed rate per student). Federal co-funding is determined by a formula based on the number of students (70%) and the acquired project funds (30%). The share of different funding sources varies rather strongly by university.

c) *Universities of Applied Sciences* are mostly financed by the cantons: the core grant includes a (formula-based) educational component and a negotiated research component, which however is much lower than for universities. Federal funding is purely

student-based. Therefore, UASs have a much lower level of institutional research allocation than universities and are expected to fund most of their R&D from project funds.

This allocation model has been quite stable since the late 90s.

3.4.3 Project funding

Figure 8 provides an overview of the main project funding instruments in Switzerland; this structure has been quite stable over the last decade, except a rapid increase in the funding from EU-FPs.

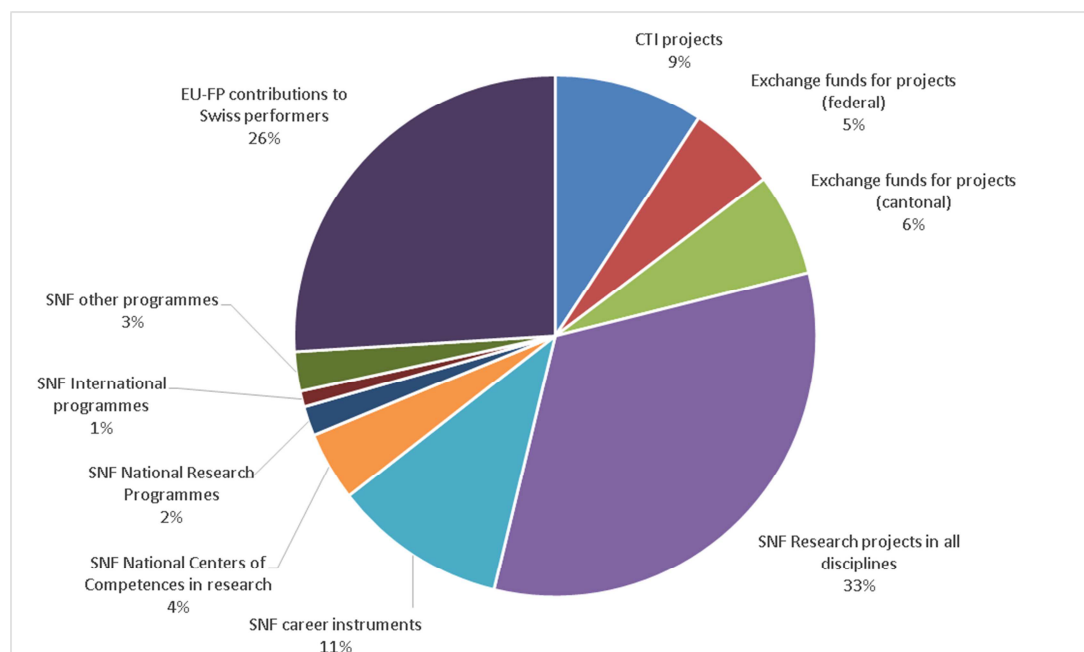


Figure 8. Structure of public project funding of R&D in Switzerland, 2012.
Source: SFSO, preliminary elaboration for the PREF project.

a) The Swiss National Science Foundation is by far the largest national funding agency. Its main instruments are:

Investigator-driven projects oriented towards the development of basic knowledge, scientific publications and PhD theses (about 2/3 of SNF budget and 40% of total project funding). These projects are on topics proposed by the investigators themselves and are selected based on the outcome of international peer review. Success rates are between 40% and 50%. In addition to regular projects, specific schemes for interdisciplinary projects and small research networks (Sinergia) have been established.

Different *career grants* in order to promote the academic careers of young researchers, including mobility grants for periods abroad, post-doctoral grants in Switzerland (Ambizione grants) and SNF assistant professorship grants. All these grants are selected based on peer review and selection rates range between 20% and 50% depending on the type of grant. While career grants amount to only about one-fifth of the SNF budget, a very large number of PhD theses is supported through research projects.

National Research Programs (NRP) are programs aiming to devise solutions to urgent societal and political problems, in domains like healthcare, energy, society, culture, technology. The selection of topics is made by the SERI and the final decision on which programs to launch is made by the Swiss government; SNF manages the project selection process through international peer review and a committee composed by academics and practitioners. Since their introduction in 1975, 75 NRPs have been launched.

National Competence Centres of Research (NCCR) are national research networks that aim to elevate Swiss research to a higher international level in a specific field or around a specific topic. About five to six NCCRs are launched during every four-year period based on an open call for proposals and selections by international panels. They are supported for a period of 8-10 years.

Finally, SNF manages a large number of international research programs, including a program for development cooperation (R4D), cooperative projects with Central and Eastern European countries and emerging countries, like China and Brazil.

The main allocation criterion for the SNF is the scientific quality of the proposal and the academic track record for the applicants. In program research, relevance for social and economic problems is an important criterion; while the application potential may be an advantage, according to its statutes, SNF cannot fund research with direct commercial interests (and results of SNF projects have to be openly accessible).

b) The *Commission for Technology and Innovation* mostly finances cooperation projects between public research and private companies. These projects are strongly oriented towards the creation of market value thanks to research innovation; CTI provides funding to the public partner in order to perform R&D activities responding to the needs of the private partner. The company has to finance half of the project costs, mostly for the salaries of its collaborators, but owns and can commercially exploit the project results. This scheme proved to be quite effective in supporting R&I in SMEs with limited in-house research capacity. Additionally, CTI manages a number of measures supporting technology transfer and entrepreneurship, which are described in detail in chapter 5 of this report.

The main evaluation criterion for CTI projects is the economic potential for proposed innovation in terms of added value and the creation of new employment; this is usually portrayed in a detailed business plan, which is an integral part of the submitted application.

c) *European Framework Programs*. European Framework Programs have become a major source of project funding for Swiss researchers. Both in the 6th FP and 7th FP, Switzerland was by far the associated country with the most participations in EU-FPs, with about half of the participations from associated countries. With more than 4,000 participations and 1,000 coordinators in FP7, Switzerland ranked 7th among all participating countries, after the five largest EU countries, the Netherlands and Belgium

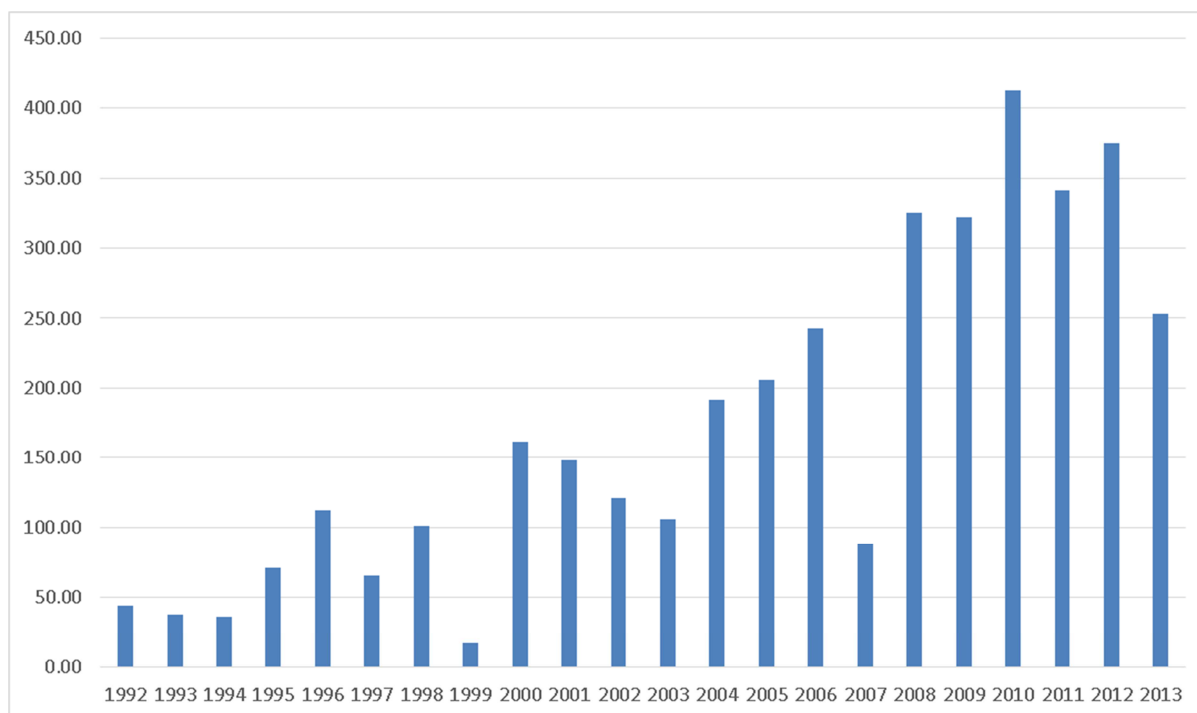


Figure 9. Funding to Swiss researchers associated with EU-FP, 1992-2014.
Source: SERI. Both Swiss and EU funding for project participation.

The growth was particularly strong since Switzerland became associated with EU-FPs in the year 2004 (Figure 9). The current situation regarding participation in Horizon 2020 is characterized by some uncertainty, since only a partial association was achieved (see further in section 4.2.1).

3.4.4 Other allocation mechanisms

Beyond projects managed by the SNF and CTI, other federal ministries are still providing substantial amounts of R&D funds in the form of contracts. These funds, conforming to the Frascati manual, are included in project funding in the breakdown of GBARD.

The corresponding amounts however decreased in the last two decades, as most new policy-relevant initiatives have been executed by the SNF and by the CTI. This applied for example to the development cooperation program R4D (co-funded by Swiss Cooperation and Development Agency) and to the new energy research program (see section 2.2).

Public procurement is now gathered under the definition of exchange grants stipulated in the new version of the Frascati manual (OECD 2015), i.e. those public funds for which the State receives in exchange for funding research services and results for its use (for example for the implementation of public policies).

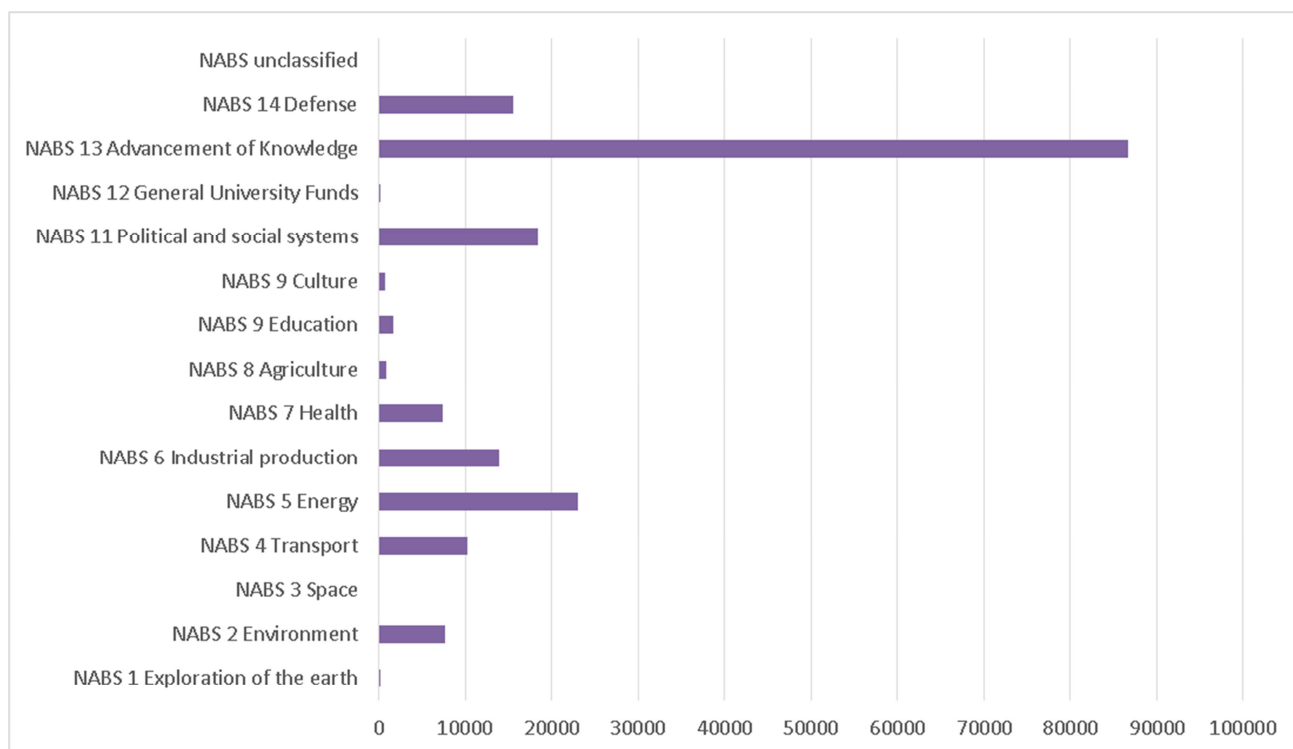


Figure 10. Exchange grants. Classification by NABS, 2014. Source: PREF project based on SFSO data. Cantonal exchange grants cannot be classified by NABS.

As shown by Figure 10, the most important policy domains are currently energy (particularly energy demonstration projects, political and societal systems, defence and health).

3.5 Public funding for private R&I

3.5.1 Direct funding for private R&I

There are no national programs to directly support R&D in private companies in Switzerland. This is the outcome of a clear-cut political decision that State support should focus on the public sector, while companies should directly fund their own R&D. The association of the private sector supports this policy and, particularly via large multinational companies whose R&D budgets far exceed the public R&D investment.

The lack of direct funding does not imply a lack of support for private R&D. The main financial mechanisms to this aim are joint projects between public research institutions (including HEIs institutes) and companies funded by the Swiss Innovation Agency (see above section 3.4.3). This funding mechanism is particularly tailored to the needs of SMEs without strong in-house research capacities. Particularly, since the late 90s, the creation of Universities of Applied Sciences strongly contributed to the reinforcement of collaborations between SMEs and the public research system.

Evaluation studies provide a very positive picture of the impact of this instrument: CTI projects lead to an increase in the R&D effort of the involved companies, to a reinforcement of the collaboration between higher education and companies and to the creation of additional R&D competences within the companies themselves; finally, there are clear effects on the innovative activities of companies (measured by the number of patents) and on their market position (Hotz-Hart B., Rohner A. 2013).

The specific measures to support start-ups and innovative companies and for innovative markets are reviewed in chapter 5 of this report.

3.5.2 Indirect financial support for private R&I

In Switzerland, support of R&D via tax incentives is extremely limited (KPMG, 2011) and, with 0.02% of GDP is one of the lowest among OECD countries (Source: OECD). Some reasons for this neglect of R&D tax incentives are the reliance on favourable local conditions for businesses, a high intensity of private R&D expenditures and the existence of special fiscal regimes favouring foreign enterprises established in Switzerland.

The issue however has been debated and there have been proposals to introduce such regimes (KPMG 2011). In June 2015, the Swiss government has submitted to the parliament a general reform of taxation rules for enterprises, which also plans for the introduction of R&D tax incentives (Schweiz. Bundesrat 2015a).

This reform follows widespread international critiques on the possibility for Swiss cantons to apply a more favourable taxation regime on company benefits for so-called mobile companies, i.e. companies whose location is not fixed (like holding companies or off-shore companies), as such practices are increasingly considered discriminatory.

In the framework of this reform, to maintain the fiscal attractiveness of Switzerland for foreign enterprises despite the abolishment of such special fiscal regimes, the introduction of more favourable treatments for R&D and innovative activities is planned, following widespread international practices. First, a so-called patent box will be created, i.e. the more favourable treatment of revenues from patents and licensing practices. Second, cantons would have the possibility to allow the deduction of R&D expenditures performed by the company from its fiscal liabilities.

The parliamentary discussion of the reform proposal is planned for 2016; the reform is politically controversial particularly because of the important loss of fiscal revenues for cantons and the Confederation, therefore, it is not possible to predict the final outcome of the debate at this time. In general however, most policy and economic actors are open to some type of indirect support to private R&D and innovative activities.

3.5.3 Innovative public procurement

Unlike a few other European countries, innovative public procurement does not play a relevant role in public policies in Switzerland. This situation has been attributed to the conservative and policy controlled practices of public procurement, which would lead to a low risk-taking attitude from public authorities (Hotz-Hart, 2012). The proposal for a new Swiss procurement act, which is currently under preparation, takes a small step forward by explicitly indicating the innovation potential as a secondary criterion to be taken into account in public procurement.

Switzerland is also currently excluded from relevant instruments on innovative public procurement in Horizon 2020.

3.6 Assessment

The main characteristics of the public R&D funding system in Switzerland can be described as follows:

- The level of public R&D spending is comparatively high and has constantly increased in the last decade, so that Swiss public research enjoys very favourable funding levels in international comparisons.
- Spending level and their composition display a high level of stability, which creates favourable conditions for public-sector research.
- The lion's share of funds benefits the higher education sector, almost no funding is provided to private companies since private R&D spending is considered satisfactory. There are however effective instruments promoting public-private cooperation and indirectly supporting the R&I activities of SMEs.
- There are almost no tax incentives to private R&D. The situation may change in the future as there are on-going debates on reforming the enterprises' taxation policies.

- The system builds on the complementarity between weakly competitive institutional funding – where the distinction is made between types of HEIs – and competitive project funding, which is mostly oriented towards basic research and assigned based on international peer review. The balance shifted towards project funding in the last decade. Institutional funding was made slightly more competitive in the late 90s.
- The system is rather decentralized and driven by investigators' and companies' interests and needs; top-down policy governance in terms of research topics and strategies are quite limited.

Overall, the public research system provides a good ecosystem of funding schemes which allow the attainment of different goals – i.e. the development of basic research, human capital formation in R&D, R&I in the private sector – via means of complementarity.

4. Quality of science base and priorities of the European Research Area

4.1 Quality of the science bases

As shown by Table 4, the quality of the Swiss system is excellent. Switzerland accounted for 1.2% of all Web of Science publications in the world in 2009, coming in 18th place worldwide and seventh place in Europe (Staatssekretariat für Bildung, Forschung und Innovation SBFI 2014d). The share of publications among the top-10% cited was almost 20% and was the highest of all European countries, reaching a similar level as the US. This leading position in international sciences has been quite stable over the last two decades and is particularly strong in sciences and health. Switzerland's research is also one of highest proportions of international co-publications worldwide, reflecting the high level of internationality of its research system and, particularly, of university academic staff (see further in section 4.4).

A similar picture is provided at the institutional level by international rankings: in the size-independent impact-based Leiden ranking, EPFL ranks second in Europe after Oxford and ETH Zurich at fifth, while seven Swiss Universities are among the first 300 in the Shanghai ranking (with ETH Zurich in 20th place). This emphasizes the overall quality of the Swiss university system, which is not limited to a couple of excellent institutions. Besides the university system, a strong contribution to Swiss research output is provided by some research institutes (Paul Scherrer Institute and EMPA), by international organizations (World Health Organization and CERN), as well as by companies like NOVARTIS and Roche, who rank among the top-publishing companies worldwide.

There are several reasons for this excellent scientific performance. First, the Swiss research system is well funded, both in the public and in the private sector. Second, public policies for R&D are characterized by stability and long-term planning and by a consistent orientation of funding instruments towards the science base, particularly through the Swiss National Science Foundation (see section 3.4). Third, the university system is highly decentralized and universities enjoy a very high level of autonomy in managing their research and maintaining academic standards. Fourth, Switzerland enjoys a very open and deregulated labour market for researchers, which is highly attractive for foreign researchers, and a consistent policy for the training of PhD students and young researchers by universities (see section 4.4).

A similarly favourable picture is provided by the indicators on technology and economic innovation presented in chapter 5 of this report.

Table 4. Data on the Science base. Source: European Commission.

Indicator	CH	EU average
Number of publications per thousand of population (full counting)*	4.53	1.43
Share of international co-publications*	64%	36%
Number of international publications per thousand of population*	2.89	0.52
Percentage of publications in the top 10% most cited publications**	20%	12%
Share of public-private co-publications	4.9%	1.8%
*2013		
**2010		
**2011-2013		

4.2 Optimal transnational co-operation and competition

To understand the transnational and international cooperation strategy of Switzerland concerning R&I, it is necessary to take into account two important framework conditions.

First, the Swiss R&I system is highly internationalized both in its public and in its private component, largely as an outcome of a traditionally varied and export-oriented economic system. The size of the country and its public R&D system also leads to a traditional policy of strong opening and international collaboration in research: Switzerland therefore participated from the beginning in most international research cooperation initiatives and had a very international labour market both for researchers in both the public and private sector.

Second, the relationships with the European Union have been particularly complex and subject to change over the last four decades. While in R&D policy the wish to cooperate has largely prevailed, some obstacles have been generated by the status of general Swiss-EU relationships. We shortly review below the implications of this situation, as well as current uncertainties in the system.

4.2.1 Joint programming, research agendas and calls

Switzerland has participated from the beginning in most European multilateral public sector R&D initiatives, including full membership in CERN (1954), the European Space Agency, COST, EUREKA; since 1978, Switzerland also participates through a specific agreement in the nuclear fusion (ITER) and plasma physics activities of the EURATOM program. Participation in Swiss research groups in earlier EU-FPs was possible thanks to a cooperation agreement signed in 1987 as a third-country; the Swiss Confederation provided financial means to support Swiss participants in EU-FP projects.

The adoption of bilateral agreements with the European Union in 2004 marked a watershed for Swiss participation in the European Research Area, since Switzerland was now fully associated with the 7 EU-FP and, therefore, was also allowed to participate in individual grants (European Research Council grants; Marie Skłodowska-Curie grants), and in most joint programming initiatives.

The growing importance of international activities is demonstrated by the strong increase in the share of GBARD devoted to international contributions: in 2012, more than one-quarter of the national public investment in R&D was devoted to international activities (Figure 11).

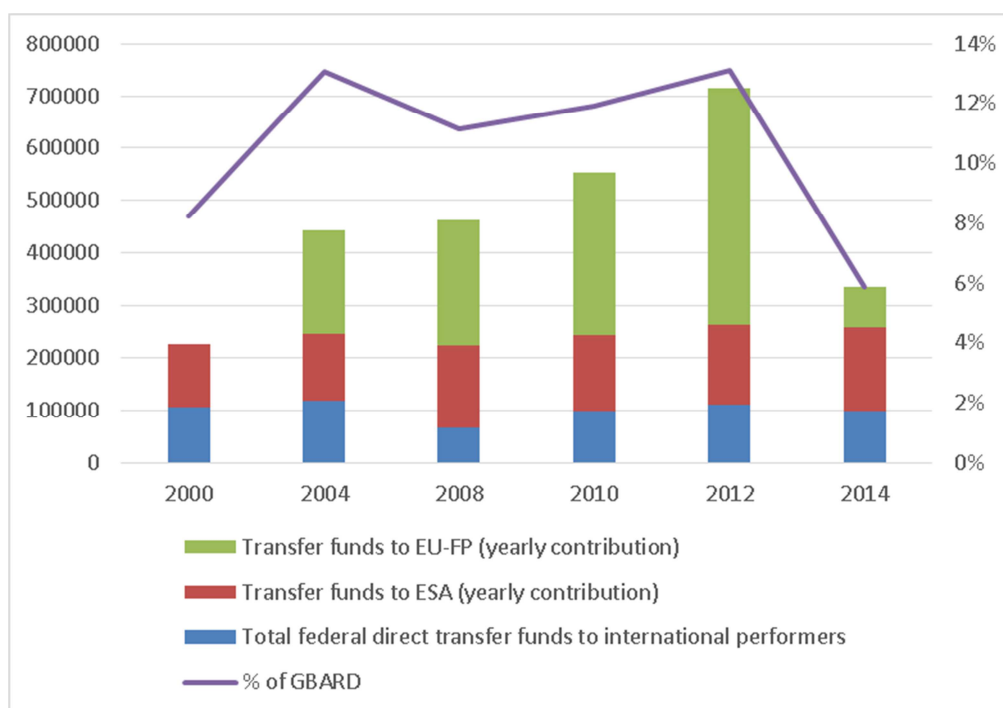


Figure 11. National funding to international funding agencies and programs.
Source: data collection from the PREF project. The strong decrease in 2014 is due to the non-association in Horizon 2020.

However, a high level of uncertainty characterizes the current situation. After the vote on the immigration initiative in the spring of 2014, Switzerland was not able to sign the extension of the free movement of persons with Croatia and, therefore, the European Union suspended negotiations for an association in Horizon 2020. Switzerland was therefore set back to third-country status in H2020 with the option to participate in collaborative projects; funding for Swiss participants is now provided by the SERI, thus adopting similar rules as for full members.

Additionally, an agreement for a partial association has been concluded: the agreement is valid for the period between September 2014 and the end of 2016: this agreement allows full participation of Swiss researchers in the Excellent Science pillar of H2020 (ERC, FET, MSCA actions and research infrastructures), as well as to Euratom and ITER. Most other actions of H2020 remain accessible to Swiss researchers as a third-party country, with the exception of measures for access to risk finances and innovation in SMEs, which are closed to Swiss partners.

The outlook after 2016 is very uncertain. The European Commission made clear that after 2016 either Switzerland will become a fully associated country in H2020 or be reverted back to third-country status (which would imply exclusion from most Excellent Science activities). The full association is conditional on a solution to the issue of free movement of persons and, particularly, to its extension with Croatia.

Participation in European Joint programs

Despite the fact that Switzerland is not a EU member state, Swiss research policy is closely coordinated with the ERA strategy. In this respect, Swiss research policy follows an approach based on complementarity between international and EU activities on the one hand, and domestic research policy on the other. Participation in EU joint programs is then decided à la carte when this is reasonable from a critical mass perspective (like

for many research infrastructures; see section 4.2.2) or when there is specific demand from the Swiss research communities.

At the institutional level, the coordination of the Swiss European and international research strategy is the remit of the SERI; besides general coordination, SERI manages Switzerland's representation and financial participation in international research organizations and agencies (particularly through the Swiss Space Office for ESA), and represents Switzerland in European and international committees at the EU and OECD level, while also managing their participation in EU Framework Programs and EU educational programs. A well-developed information network for Swiss researchers to facilitate their participation in EU programs (Euresearch), and a liaison office in Brussels (Swisscore) has also been established.

SERI also manages Switzerland's participation and financing in a number of multi-lateral and EU-level joint programs, including Ambient Assisted Living (AAL), Eureka and EUROSTARS, COST, and co-funding of Switzerland's participation in the Joint Technology Initiatives. Participation in ERA-NETs are decided case by case based on the needs of the Swiss scientific community and managed by the SERI or the CTI or the SNF, depending on the orientation towards technology or basic science. In the 7th EU-FP, Switzerland participated in over 40 ERA-NETs.

According to the study on Joint and Open Programs in the ERA (JOREP; Reale, Lepori, Nedeva, Thomas, Chassagneaux and Larédo 2013), Switzerland devoted about 0.9% of GBARD to joint programmes (excluding EU and ESA participation) in 2009, a percentage similar to other European countries considered in the study. The share of bilateral initiatives was however larger than for EU members states (see section 4.3).

4.2.2 RIS roadmap and ESFRI

The national research infrastructures (RIS) roadmap for Switzerland has been conceived as a planning tool in order to coordinate political decisions and financial support to RIS, which are currently divided between different funding channels. A first edition of the roadmap was produced in 2011 as an input to the 2013-2016 strategic plan. The 2015 roadmap was published in summer 2015 and constitutes the basis for the integration of RIS in the strategic plan 2017-2020 (Staatssekretariat für Bildung, Forschung und Innovation SBFI 2015). The roadmap was based on an extensive consultation process, where research organizations were asked to submit proposals for RIS through an open call; scientific evaluation was made by the SNF, while the SERI – in consultation with Swiss universities and ETH-RAT – decided on the final prioritization. The roadmap does not however have direct financial implications, since the required financial means will be proposed in the ERI dispatch 2017-2020.

Roadmap 2011. The roadmap 2011 included five national RIS, i.e. Switzerland's X-ray free-electron laser at the Paul Scherrer Institute, the national supercomputing strategy at the Swiss National Supercomputing Center managed by the ETH Zurich, the FLARE programme for the construction of instruments for international projects at CERN and ESO, the Swissgrid initiative networking Swiss universities and the Blue Brain project at the EPFL. The 2011 roadmap also included Switzerland's participation in international research organizations like CERN and ESO and Switzerland's participation in eight ESFRI Research Infrastructures for which Switzerland already signed a formal commitment (the agreement for their participation in the European Spallation Source was signed in 2015). For the period 2013-2016, 18.4 m CHF were made available for participations in these infrastructures (some participations are funded directly by the involved institutions). Currently, Switzerland cannot directly participate in European Research Infrastructure Consortia (ERIC), the legal form adopted by most ESFRI initiatives, and therefore Switzerland's participation must be negotiated in a case-by-case basis via specific agreements.

Roadmap 2015. Among the 41 research infrastructures proposed, 23 have been put in the highest priority group and will probably be funded for the 2017-2020 period. The total financial volume of these initiatives amounts to about 700 m CHF, the largest being the Swiss National Strategy for Supercomputing (210 m CHF, ETH Zurich) and the Swiss Plasma Center (135 m CHF; EPFL). The list is strongly oriented towards natural sciences, engineering (particularly IT) and health data; only three smaller RIS at the national level are in the humanities and social sciences. Funding for these infrastructures will be provided by the institutions themselves, by the ETH-RAT, and through university cooperation projects. This reflects the decentralized Swiss system, where most RIS are managed by the higher education sector themselves and not by dedicated national research facilities managed directly by the State.

Additional measures for research infrastructures are managed by the SNF through the R'EQUIP programme, which allows the funding of middle-size infrastructures in higher education institutions, which are indispensable for scientific research and through the Swiss academies of Arts of Sciences, supporting long-term publication projects (national Swiss dictionary) and research facilities. Continued participation in ESFRI RIS is also expected, and the extension to further infrastructures where an ERIC has been created or is planned. Swiss participation in ERIC was foreseen in the framework to the association of the H2020 programme, but it is currently suspended because of general issues concerning participation in EU research initiatives (see section 4.2).

Summarizing, the Swiss policy on research infrastructures is highly decentralized; most national RIs are managed directly by the universities or public research organizations (as in the case of the Swiss National Supercomputing Centre). There is also no specific national funding stream for RIS, but resources have to be found within the normal funding channels for R&D. There are however increasing attempts to coordinate such undertakings at the national level and a true national strategy is emerging in some domains, like supercomputing. A strength of this approach is undoubtedly to ensure a close collaboration between RIs and research institutions. Given the size of the country, the national policy has to be coordinated with European initiatives and, despite its specific status as a non-EU member state, Switzerland is very well connected to ESFRI activities and joined most European and international research infrastructures.

4.3 International cooperation with third countries

While not a EU-member State, Switzerland has a well-developed strategy for bilateral research cooperation with all types of countries, including European countries, developed countries like the US, emerging countries and less developed countries. This strategy follows differentiated goals depending on the type of countries and their scientific potential (Schweiz. Bundesrat 2010).

The bilateral cooperation strategy is coordinated by the SERI and implemented via different methods: a network of 28 scientific and technology advisors (STC – Science and Technology Counsellors) in the Swiss embassies in Europe, the US, Eastern Asia and South America, with the task of observing relevant evolutions in national R&I policies and managing bilateral relationships in S&T; a network of Swiss S&T houses in key cooperation countries (Boston and San Francisco; Shanghai; Bangalore, Rio de Janeiro) promoting cooperation between Swiss research organisations and foreign ones, and offering basic infrastructures for hosting meetings and networking activities; finally, a differentiated set of bilateral cooperation programs. Additionally, Swiss higher education institutions are traditionally very active in international collaboration and networking at the researcher's level, but also at the institutional level.

At the level of research programs, the following instruments are currently available for international bilateral collaboration:

- The Swiss National Science Foundation is establishing a set of so-called *lead agency agreements* with other research councils, where bilateral projects in basic research can be submitted to only one agency, but funded by both parties. Such agreements

currently exist with Germany and Austria (DACH agreement), Luxembourg, France and the UK (with some limitations).

- A set of bilateral research programs have been established with emerging countries, including China, Japan, Korea, South Africa, India, Russia and Brazil. These programmes support joint projects cofounded by the two partner countries, as well as a set of exchange grants and networking measures. Each programme is implemented by a leading house from a Swiss university, while the selection process of the projects is managed by the SNF.
- A specific program is managed by the SNF for cooperation with Eastern European countries and the Community of Independent States (CIS). It supports institutional partnerships, joint projects and exchange measures. The Swiss University Conference also managed the SCIEX program, which allowed researchers from CEEC to participate in a research stay in Switzerland. Finally, SNF also manages two dedicated programs for scientific collaboration with Romania and Bulgaria as part of the Swiss contribution to the enlargement of the European Union.
- The SNF manages a large program for the cooperation with developing countries (R4D), endowed with almost 100 m CHF for the period 2012-2022. The program is in close cooperation with the Swiss Cooperation and Development Agency and specifically aims to provide research-based solutions to development problems in fields such as healthcare, poverty, employment, and sustainable development.

It is expected that most of these measures will be extended to the new 2017-2020 funding period.

International cooperation concerning innovation is slightly less developed: while the revision of the Swiss Research and Innovation Act explicitly entitles the CTI to support international cooperation in innovation, as a principle Swiss funding cannot be provided for such activities abroad. International cooperation takes place largely within the EUREKA programme, where Swiss partners can be funded according to the normal CTI rules. Within the EUREKA framework, a number of joint calls have also been launched with partner countries, while SERI and CTI regularly organize cooperation and networking events at the international level.

4.4 An open labour market for researches. Facilitating mobility, supporting training, ensuring attractive careers and encouraging gender diversity

4.4.1 Introduction

Switzerland disposes of a well-developed, open and highly international market for R&D personnel. The total number of R&D personnel increased from about 52,000 FTEs in 2000 to 75,000 in 2012, while the share of foreign personnel increased from 29% to 39% over the same period (source: Swiss Federal Statistical Office). With 15 R&D personnel for 1,000 employed personnel, Switzerland ranked among the top-European countries after Denmark, Finland and Sweden, thus exceeding the EU-28 average by 50%; this figure increased consistently over the last two decades from 11 per 1000 employees in 1992. The sectorial repartition broadly corresponds to R&D expenditures, with about two-thirds of R&D personnel accounted for by the private economy and the remaining by higher education (see Figure 12).

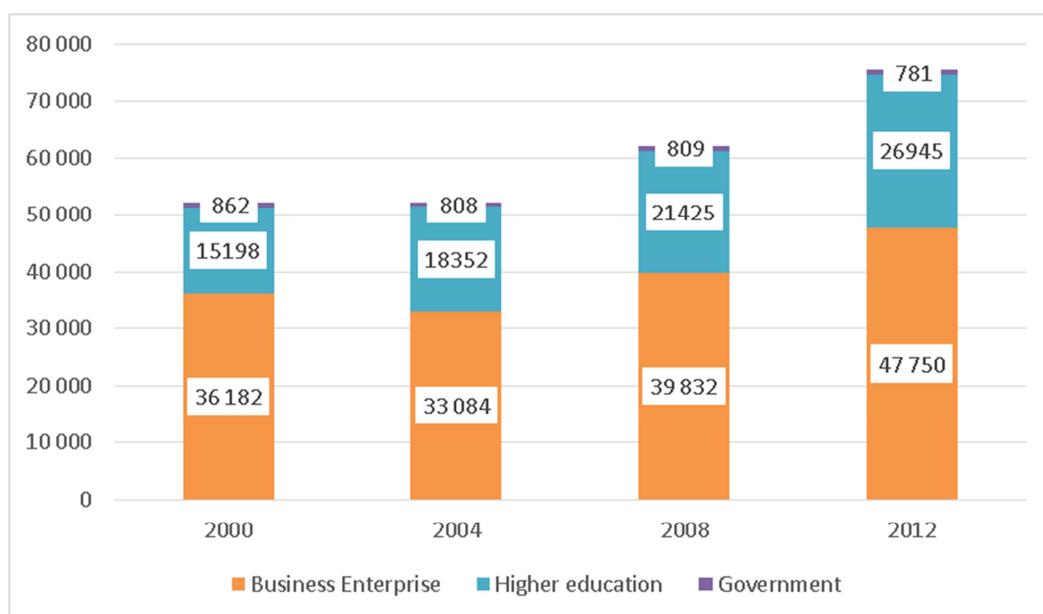


Figure 12. R&D personnel in Switzerland, FTE. Source: SFSO.

The sector distribution in the private sector largely matches the distribution of R&D expenditures, with the pharmaceutical industry accounting for 20% of FTEs in 2012, 17% by machine industries and about 10% each for precision instruments, ICT and R&D centres.

The high percentage of foreign researchers largely depends on the chronic shortage of domestic skilled manpower, particularly in the technical sector, where the number of university students has stagnated in previous decades; the Swiss R&D sector (both public and private) is therefore highly dependent on the immigration of skilled labour. It also reflects the generally open recruiting system and the high attractiveness of the country to foreign researchers, particularly since restrictions for EU citizens have been lifted (Lepori, Seeber and Bonaccorsi 2014).

The economic downturn since 2009 had no significant impact on the labour market for R&D personnel as the crisis has been less severe in Switzerland (and even so in the R&D sector) and the State was able to maintain its investment in the public R&D sector; a significant impact of the crisis however has been to increase the attractiveness of the Swiss R&D labour market for EU citizens.

The personnel of Higher Education Institutions presents a very skewed distribution, with a rather small share of professors (generally on tenured permanent positions) and, particularly in universities, a very large share of PhD students hired as a teaching assistants or in research projects, but also increasingly for post-doctoral research assistants, as well as a limited number of senior researchers (Figure 13). The situation is somewhat different in Universities of Applied Sciences, which largely build on part-time teachers who also work professionally for their educational offer.

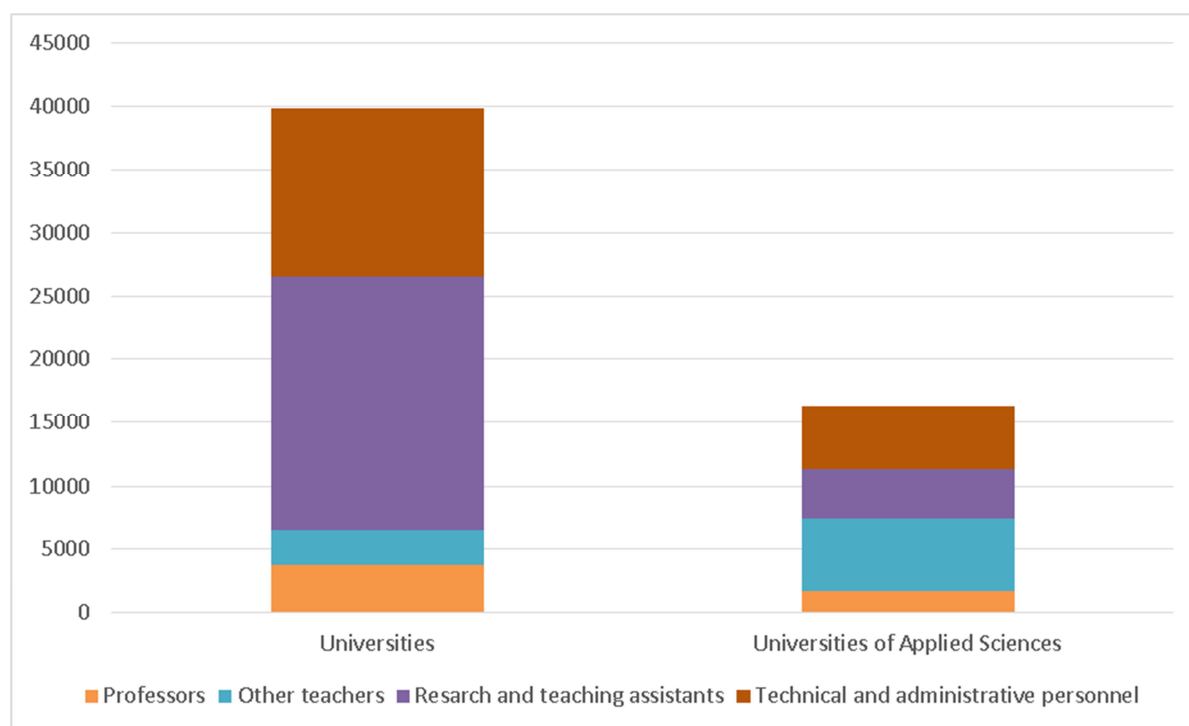


Figure 13. Personnel of higher education institutions, 2014. Source: SFSO: Both teaching and research personnel.

This personnel structure largely reflects the career structure in Swiss universities, where there are in most cases no permanent academic positions below the professor level, as well as the strong orientation of project funding (particularly by the SNF) to hire young researchers for temporary positions (3-4 years usually). This structure has a number of advantages, since it generates competition in the early phases of scientific careers, while it ensures the training of a large base of researchers, which can also be hired by private companies or by the public administration. However, increasing concerns have been raised particularly for the lack of career perspectives for postdoctoral researchers.

4.4.2 Open, transparent and merit-based recruitment of researchers

4.4.2.1 Recruitment procedures

Even in the public sector, it is difficult to provide information on recruitment procedures as the Swiss system is highly decentralized and, as a general principle, individual Higher Education Institutions and research institutes apply their own rules concerning recruitment procedures, career structure and working conditions. There are also no national accreditation procedures, for example concerning professors; this also implies that academic titles are bound to the institution and the position, not to the individual – the professor title is associated with a position with a specific HEI, not with a national qualification.

Especially at the professor level, procedures have been increasingly structured and opened in the last decades; all HEIs now have well developed procedures which attempt to ensure the independence of the selection committee (including external members in the selection panel) and govern different levels of selection, including the faculty level and the university level to guarantee the quality of the selection process. Calls for professor positions are increasingly open and international, while the nomination of local people has become rare, since in most cases the conditions of the call require international mobility. In some instances, openness has even become a subject of critique in the media, particularly concerning social sciences and humanities.

The process is less structured concerning researchers, particularly at the PhD level, where internal recruitment or direct recruitment through personal knowledge networks remains frequent, especially in social sciences and humanities; nevertheless, given also the shortage of graduates from Swiss universities willing to go into an academic career, the vast majority of positions are advertised internationally.

Universities of Applied Sciences, when considering their applied and teaching-oriented character, tend to have more local careers and recruitment procedures; however, for the professor level, structured and open procedures are increasingly adopted for new hires, while the share of foreign researchers increased rather quickly in previous years. Careers in UASs are also characterized by a much stronger permeability with the private sector, since professional experience is required in most cases for UAS teaching and research.

4.4.2.2 Staff regulations and working conditions

Traditionally, academic staff in the public sector were subject to public law and, particularly, professors were attributed a civil servant status, with well-defined conditions in terms of pensions, salary scales and retirement age. This also applied to non-academic staff and to most research staff.

Since the 90s, regulatory reforms have provided HEIs with increasing autonomy in determining appointment conditions, in particular for non-professor staff, which can be hired on temporary contracts based on civil law. However it is difficult to provide a general overview, since regulations differ between HEIs (generally, German-speaking HEIs enjoy more autonomy than French-speaking HEIs in this respect).

In general, professor staff is still employed on a permanent basis and subject to more binding regulations in terms of salaries and retirement age, but some flexibility has been created. For example, for the two Federal Institutes of Technology, the ETH-RAT has the right to appoint professors above the legal retirement age (65 years) when their scientific performance is excellent. Assistant professors are hired mostly on a temporary basis (usually 4 to 6 years), but universities are increasingly introducing tenure track positions, where assistant professors can be promoted to (tenured) associate professor positions after an evaluation of their scientific performance.

The researchers' level has been more extensively deregulated, but framework conditions usually apply concerning employment periods and salaries. For most positions and universities, a six-year cap applies, i.e. post-doc researchers cannot stay in the same position longer than six years in most cases. This corresponds to the general rule that all university positions aside from professors should be temporary.

Working conditions for PhD students are above average when compared internationally, as most are employed as research assistants with reasonable salaries for the entire duration of their PhD. The SNF introduced a minimum level of salary, currently around 45,000 euros p.a., which is respected by all institutions; higher salaries are provided by some HEIs in the technical sector, since finding good candidates otherwise would be difficult. The maximum time for completing a thesis is six years in most cases.

The situation is less structured for post-doctoral positions: salaries are higher (in the range between 70,000 and 90,000 euros p.a.), but most contracts are shorter and based on the availability of project funds. The role and position of post-doctoral researchers in the Swiss system remains a source of concern (see below).

A strength of the Swiss system is a well-developed personal grant system by the Swiss National Science Foundation, with the clear goal of offering respectable career opportunities to the most brilliant researchers. At the doctoral level, so-called Doc.CH grants allow the best master students in social sciences and humanities to pursue an independent PhD thesis; mobility grants are also available for PhD students and PhD graduates for a stay in a foreign research institution (up to three years for PhD

graduates). At higher qualification levels, Ambizione grants allow highly qualified post-docs to independently develop their own research, while the SNF assistant professorship provides the entry stage at the professorial level, endowing successful candidates with a salary and a fully funded research team. These programs have been highly successful in promoting academic careers, for instance 90% of the past SNF professor grantees have in the meantime won a permanent professor position (Fonds National Suisse 2007; Balthasar and Iselin 2014).

Return conditions for Swiss researchers with a stay abroad are generally quite favourable, given the lack of national candidates for many academic positions.

4.4.2.3 International opening

As already witnessed by statistical data on the number of foreign researchers, the Swiss researchers' labour market is very open internationally, both in the public and in the private sector. Besides the lack of explicit discrimination and an increasing emphasis on international mobility in recruitment, this is also favoured by the wide diffusion of English as the main working language in Swiss research, as well as in the public sector. Particularly in science and informatics, most master curricula are currently offered in English, while Swiss universities tend to be flexible concerning competences in national languages; additionally, a large share of foreign applicants come from neighbouring countries (Germany, Italy and France) and already master the relevant national language.

Within universities, the increase in foreign academic staff was indeed impressive, from about 20% in the early 90s to the current level of 48%; this increase has taken place at all levels of the academic hierarchy, from PhD students to professors. Excluding very small countries like Luxembourg, Switzerland has by far the highest share of foreign academic personnel among European countries.

Issues concerning international recruitment are more related to general labour market regulations and general immigration policy, which continues to be major concern in Swiss policy since the Second World War (Piguet and Mahnig 2000, Fischer, Nicolet and Sciarini 2002). Since 2004, bilateral agreements with the European Union implied the abolishment of the former quota system for European citizens and of the priority for nationals in the labour market; restrictions remain however for non-EU citizens, in particular for researchers – the regulation is more liberal for PhD students, given their status is as students. The entire Swiss research landscape was compact in supporting the opening of the Swiss labour market, as it was considered that international openings are necessary and beneficial to the quality of Swiss research.

The acceptance of the immigration initiative in the 2014 (see section 1.1) and the ensuing debate on its application generates uncertainty concerning the future regulation of the Swiss labour market; its impact will largely depend on how the new planned quota system will be implemented and whether, as before 2004, the praxis for the research sector will remain more liberal than for the general economy.

4.4.2.4 General assessment

The entire system of the Swiss researcher's career promotion has recently been evaluated by the SERI; this followed claims that the situation for young researchers was not optimal and characterized by uncertain perspectives (Schweiz. Bundesrat 2014).

The report generally acknowledges the excellent quality of the Swiss system and that higher education strongly contributes to the provision of skilled research in the private sector, thanks particularly to the large number of PhD graduates. The high level of internationality and international mobility of researchers contributes particularly to its quality.

At the doctoral level, a major issue is represented by the limited attractiveness of a PhD for Swiss students –only half of the PhD students currently enrolled at Swiss universities

obtained their master degree in the country. Suggested improvements include a progressive increase of PhD salaries, which are currently not competitive with positions in the private sector, a reduction of the administrative and practical tasks (like preparing course documents or managing exams) contained in PhD student's job descriptions and the introduction of a protected share of weekly working time for completing the dissertation. Such issues are considered to be particularly relevant in social sciences and humanities.

The report highlights structural problems, especially at the post-doctoral level. According to estimations, in 2011, between 5,000 and 8,000 post-doctoral researchers were employed in 2011 by Swiss universities, against slightly less than 3,500 professors and only 600 assistant professors. These data show that there is lack of structured positions between the PhD level and the professor level and that the post-doctoral level is populated by a large number of persons with a rather uncertain status and perspective. The report recommends a better structuring of post-doctoral positions, with clearer selection rules that would also avoid individuals staying in the academic system for a too long when they have limited chances of obtaining a professor position. While this report will have no direct consequences, it is expected that some measures to address these issues be formulated in the strategic plan for the 2017 to 2020 period (see section 2.1).

4.4.3 Access to and portability of grants

Access to grants. Overall, rules concerning academic personnel in Swiss universities make no distinction between Swiss and foreign applicants, provided they are employed at a Swiss institution. The same applies to personnel engaged in SNF-funded projects. Barriers to engaging foreign researchers mostly originate from the labour market and immigration regulations. As for personnel grants, nationality is not a relevant criterion, but for most SNF grant schemes some kind of relationship with Switzerland is required, like a Swiss diploma or a few years of activity in a Swiss research institution. The SNF programme Ambizione however allows researchers without a prior relationship with Switzerland to apply for post-doctoral positions in a Swiss HEI.

Access to national project funding by researchers affiliated with foreign institutions remains the exception. At the SNF, a foreign partner is allowed in countries with a bilateral cooperation agreement, including Germany, Austria, France and the UK, and in most cases through funding of the respective national research council. A notable exception is the Sinergia instrument, which allows funding of a research group from abroad within a consortium of three to four research groups, provided its competences are critical for the success of the project.

Access from abroad to CTI funds is exceptional, in some cases foreign research groups might be involved if a Swiss company then owns the results.

Portability of grants. Swiss national Science Foundation grants, which constitute the largest share of project funding at the national level, are portable in most cases, meaning that, if the researcher moves abroad, a project which has already begun can be transferred to the new institution (and the scientific personnel hired or moved there). CTI grants are usually not portable, since they explicitly aim to create economic value in Switzerland.

4.4.4 Doctoral training

A specific strength of the Swiss system is the ability of the Swiss universities to train a large number of doctoral students. With the share of the population aged 20 to 29 studying on the PhD level at 1.94%, Switzerland ranks among the top of European countries with almost double the European average and the PhD intensity (i.e. the ratio between PhD graduates and undergraduate graduates) of Swiss universities was more than two times the European average.

There are different reasons for this high importance of PhD education in Swiss universities. On the one hand, lacking a structured researchers' career, PhD students

constitute most of the manpower for R&D within universities, particularly in science and medicine, where a large R&D personnel is required for experimental work. The Swiss funding policy is also strongly oriented towards the funding of PhD students, since it is considered that this contributes most to human resources formation: for example, more than half of the researchers paid on SNF projects in 2014 were PhD students. Furthermore, outside academia, there is a strong demand for universities' PhD graduates from private companies active in R&D, particularly multi-national companies. PhD graduates are also a sought profile for many high-level functions in the public administration sector. While reliable data do not exist, it is clear that most PhD graduates in Switzerland leave academia at a relatively early stage and an academic career is not necessarily the main reason for a PhD.

Of the 20,000 doctoral students enrolled in Swiss Universities in 2009, around 11,000 were in Science and Engineering while 50% came from abroad, showing the openness and competitiveness of Swiss Universities (source: SFSO). However, in Switzerland there is little growth in the mathematical, scientific and technical areas of study (especially female students). In contrast, subject areas such as communication sciences, teaching and psychology are increasingly popular among students. The future need for scientists and engineers can be covered only partly by the influx of foreign personnel. It is therefore essential to increase the recruitment of students completing their studies in scientific and technical areas in order to augment the reservoir of available qualified people. Similar issues are currently being discussed for the education of medical personnel, where the number of doctoral graduates from Swiss universities by far does not cover the demand; the Federal Council announced a package of measures to improve the situation in February 2016.

PhD education is also strongly promoted by the SNF: about half of the personnel paid through SNF grants are at the doctoral level and doctoral dissertations and the training of researchers is considered to be one of the main outcomes of these projects (alongside scientific publications). Moreover, SNF invests about one-fifth of its yearly budget on a range of instruments to support PhD students and researchers in their early career stages and these schemes have been progressively extended to cover all stages of scientific careers below the professorial position.

There is no general regulation at the national level concerning the organisation of doctoral studies and the use of time for PhD students. Large differences exist between scientific domains: in sciences and medicine, PhD students are usually part of larger research teams and involved in research projects which are closely connected with the topic of their dissertation. This setting is very favourable from the perspective of the time devoted to R&D and of the learned skills and technical competences; it might be slightly problematic in terms of scientific independence. In social sciences and humanities, an individual model, with a PhD student working independently on their own thesis under (more or less) close supervision is more frequent. In these domains, the main problem is represented by the excessive involvement in administrative activities and in support for teaching. In general, the employment and working conditions for PhDs are however rather good and the situation has probably improved in recent years, since university departments pay more attention to the effective organization of the PhD.

The educational portion of the PhD is organized in very different ways depending on the university and field. While in some domains, especially in humanities, education is still largely left to the choice of PhD students and their supervisor, graduate schools and regulations which require a minimum number of credits acquired through PhD courses are becoming widespread. Joint inter-university doctoral education in domains where the number of PhD students in each individual university is too small has been supported in the past by the SNF (pro-doc programme) and is currently supported by the doctoral programmes promoted by Swiss universities, which shall continue at least until 2020.

In Switzerland, Universities of Applied Sciences currently do not have the right to award doctorate degrees; while the new higher education act would, in principle, leave this

option open, no change is foreseen in the next years. However, increasing cooperation is emerging in this area between universities and Universities of Applied sciences, where young researchers hired by a UAS – particularly in research projects – can jointly obtain a PhD at a university, usually with some form of joint supervision. This cooperative model responds to the specific needs of UASs to develop research competences and to expand their research basis.

4.4.5 Gender equality and gender mainstreaming in research

There has been a great deal of progress during previous decades towards levelling the gender balance in the higher education sector, but important differences remain, particularly at the upper level of the academic hierarchy.

The percentage of women among PhD students increased from 19% in 1990 to 39% in 2012, and it can be assumed that gender equality will be reached in a few years. A strong imbalance still characterizes the professor level, even if a marked improvement is visible: the percentage of female professors increased from a very low 4% in 1990 to 18% in 2012, but progress is quite slow (Schweiz. Bundesrat 2014). There are however strong differences between scientific domains, with women's presence being much lower in sciences and engineering than in social sciences and humanities. The situation is slightly better in Universities of Applied Sciences, where women accounted for one-third of all professors in 2012.

Studies have been conducted to investigate the presence of discrimination against women in the hiring process of professors, respectively by SNF grants; in both cases, they conclude that no overt discrimination takes place, but the lower number of women is due to the fact that they leave the academic career at earlier stages largely because of the difficulty of combining academic career and family.

To promote gender equality in academia, Swissuniversities manages a program on gender equality since the year 2000: the program aims to create gender equality offices at Swiss higher education institutions, providing coaching and training to women and developing childcare structures. A number of measures have also been taken by the SNF. These include methods for mentoring young female researchers, a special support for women partially leaving their research jobs due to family reasons and a special grant program for women returning to the academic career.

Gender mainstreaming is also taken into account when nominating staff to leading positions within universities (for example rectors) and at the SNF; calls for these positions usually stipulate that, with the same level of competences, women should be preferred.

4.5 Optimal circulation and Open Access to scientific knowledge

4.5.1 E-infrastructures and researchers electronic identity

Switzerland has a reasonably well-developed e-infrastructure policy and organizational structure for e-services. Most services for the academic community are provided by the SWITCH foundation (www.switch.ch), a foundation of the Confederation, cantons and universities created in 1987 with the original aim to manage the higher education Internet network. In the meantime, SWITCH services expanded to cover a whole range of e-services, including authentication access (AAI), cloud computing, e-learning and videoconferences.

SWITCH is actively involved in the large-scale programme on "Scientific information: Accessing, processing and saving" launched by the Swiss Confederation for the 2013-2016 period (<http://www.swissuniversities.ch/en/organisation/projekte-und-programme/suk-p-2-wissensch-information-zugang-verarbeitung-speicherung/>). The program aims to develop and implement through pilot projects a national strategy concerning scientific information, covering domains like access to scientific publications, data repositories, licensing, e-learning and cloud computing. The program is organised in four main pillars, i.e. publications (access and digital publications), eScience (access to

scientific data), infrastructure (cloud infrastructure and services) and services (elearning, publication repositories). While these initiatives are developed by the public sector, in principle they are also open to private partners for non-commercial use.

The importance of electronic infrastructure is attested by the fact that the research infrastructure roadmap for the 2017 to 2020 period (see section 4.2.2) includes three major initiatives in the e-infrastructure domain:

- The Swiss High Performance Computing and Networking Initiative (HPCN/HPCN-20) aims to develop the advanced computing infrastructure for Swiss researchers around the Swiss Supercomputing Centre (CSCS), including further upgrades for computational hardware and the development of application tools for scientific purposes. The initiative will be managed by CSCS in collaboration with all Swiss universities.
- The Initiative for Data Science in Switzerland aims to create competences and infrastructures for the storage and handling of large amounts of data needed in data science applications, including the interface with commercial providers of cloud services. The two federal institutes of technology will jointly manage this initiative.

The Swiss edu-ID and the Swiss Academic Cloud managed by SWITCH will aim at upgrading the Swiss university network, establishing a Swiss edu-ID as a common identity management platform for the entire higher education system and develop a cloud infrastructure for the Swiss academic community.

4.5.2 Open Access to publications and data

Policies for Open Access in Switzerland are mostly being developed by the research institutions themselves, by scientific academies and by the national funding organizations, with the complementary support of the State.

Most Swiss research institutions signed the Berlin declaration on Open Access and most university libraries now run repositories to allow for access of pre-prints and digital copies of PhD theses. The main national funding agency, SNF, endorsed a policy for open access and, since 2013, has allowed researchers to bill publication fees as project costs for pure OA journals (gold open access). Hybrid Open Access is not supported. Since 2014, SNF extends its open access policy to cover books, which remain a frequent publication form in social sciences and especially humanities: after complaints by researchers in social sciences and humanities that book open access is highly problematic, a call for supporting digital book publications under OAS was launched in 2015; publishers have the option for restricted access to the digital version for two years after the publication of the printed book. The aim of this initiative is also to collect information on the use and production costs of open access book publications, particularly in the field of humanities.

The national program for scientific information (see section 4.5.1) also includes open access as one of its main strategic directions. The programme plans for the establishment of national licenses for selected publications, the creation of a monitoring study of researcher's publication behaviours and the establishment of an advisory service for researchers' on copyright and related issues. Further, support for digitalization projects featuring content of national interest is foreseen, as well as the development of digital platforms by university libraries. Most universities also require the storage of a publication copy in the institutional repository (for example journal pre-prints and digital copies of PhD theses).

No recent estimates are currently available on the share of Open Access publications, but according to the latest European studies, in the period 2008-2013 about 60% of scientific publications in Switzerland had some form of open access, but less than 10% had gold open access (Science-Metrix 2014).

5. Framework conditions for R&I and science business cooperation

5.1 General policy environment for business

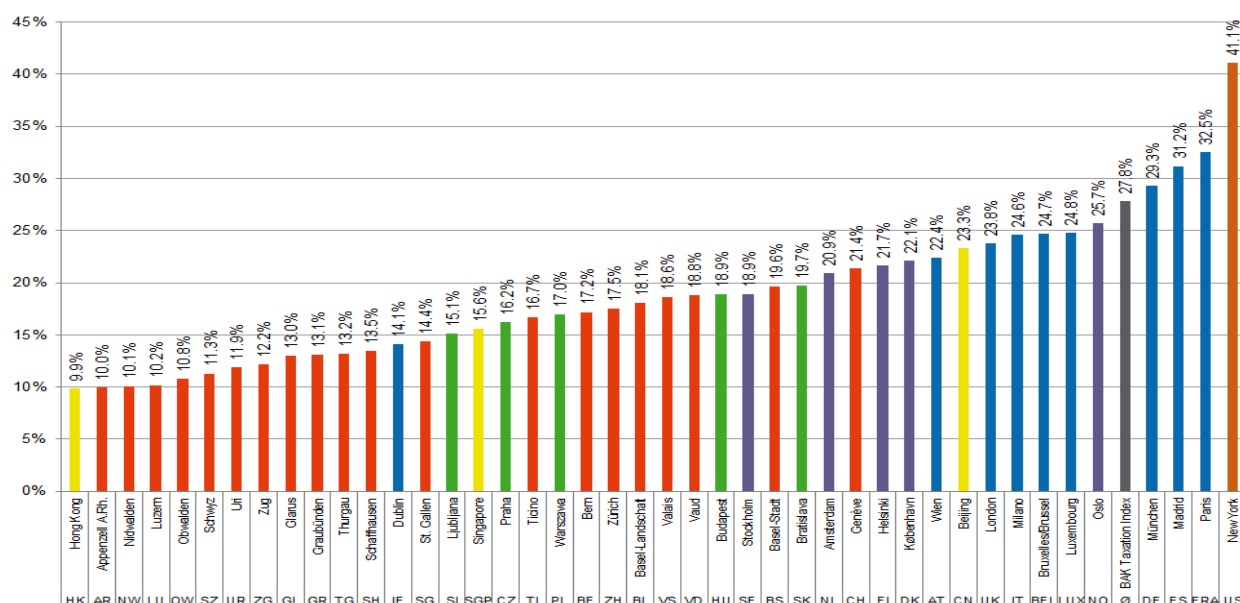
Switzerland can be considered as one of the most successful business locations worldwide. The Confederation offers an overall favourable investment environment, skilled labour, a competitive infrastructure as well as top-ranked universities and research institutions (SECO, 2015). Beyond that, taxes are relatively low and prices are stable. The table below shows how Switzerland is ranked by the World Bank in its Doing Business Index (DBI).

Table 5. Doing Business Index. Rank of Switzerland (1-189). Source: Doing Business Index, World Bank.

Ease of doing business	Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting credit	Protecting minority investors	Trading across borders	Paying taxes	Enforcing contracts	Resolving insolvency
20	69	45	5	16	52	78	22	18	22	41

As per the taxation system, the graphic below shows that both the Confederation and the cantons are, internationally speaking, very competitive and attractive. These figures refer to the BAK Taxation Index 2013-2014 and they show the Effective Average Tax Rate (EATR). Some Swiss cantons come at the top of the international ranking and all of them lie below the BAK Taxation Index average of 27.8% (BAK Basel, 2013).

Table 6. BAK Taxation Index for Corporations, international comparison. Source: BAK taxation Index



In regards to holdings, in Switzerland national holdings are not taxed, whereas international holdings established in the Confederation enjoy important privileges.

The international vocation of Switzerland and its commitment with the free market economy defines the *modus operandi*. Switzerland ranks 5th in the Freedom Economic Index (FEI, 2015). As of 2015 the Confederation has signed off 40 Free Trade Agreements (FTAs) around the world (SECO-EFTA unit). The international opening of Switzerland is also manifested by the fact that some of the biggest MNCs are headquartered in the Confederation: Glencore, Nestlé, Novartis, Zurich Insurance Group, Roche, Credit Suisse, UBS, ABB among others. Foreign companies also represent an

important part of the Swiss economy. Since 1995, foreign companies accounted for more than 20% of Switzerland's GDP growth (Swiss-American Chamber of Commerce, 2006).

The Swiss legal framework contributes to strengthening Switzerland's international attractiveness. Among the major laws governing Foreign Investment in the confederation are the: Swiss Code of Obligations; Lex Friedrich/Koller (LAFE); Securities law and; Cartel law (Arrivillaga & von Schnurbein, 2014). First, the Swiss Code of Obligations is part of the Swiss Civil Code. It regulates contract law and corporations. Following the Swiss tradition of ensuring an open economy, the Code is governed by the principle of freedom to contract. It is interesting to mention, in order to highlight Switzerland's strength and tradition in commercial laws, that the first version of the Swiss Code of Obligations entered into force in 1883 (Swiss Code of Obligations, 2015). Second, the LAFE entered into force in 1983 and regulates and limits the acquisition of real estate by foreigners (Federal Council, RU 1984 1148).

Third and with regards to the main laws regulating the Swiss securities market the Stock Exchange and Securities Trading Act (SESTA) – which was adopted in 1995 – should be mentioned, as well as its implementing ordinances such as the Stock Exchange and Securities Trading Ordinance (SESTO, 1996), the Ordinance of the Swiss Financial Market Supervisory Authority on Stock Exchanges and Securities Trading (SESTO-FINMA, 2008) and finally the Ordinance of the Swiss Takeover Board on Public Takeover Offers (TOB-Ordinance, 2008). The overall intention of the SESTA is to protect individual investors and ensure that the market place operates efficiently (CMS, 2012). Fourth, the Cartel Act (CartA, 1996) has been geared to prevent the harmful economic or social effects of cartels as well as other limits of competition and through that, to promote competition in order to strengthen Switzerland's liberal market economy (Federal Council, 2016).

In spite of these favourable conditions, the Swiss market also presents some weak points for foreign investors and companies. First, the Swiss market is highly competitive. Second, the Confederation is placed at the epicentre of European and global competition. Third, companies may encounter difficulties facing EU regulations and standards focusing on product quality and packaging. Fourth, in considering the chemical and pharmacological industry, there are specific ad hoc Swiss requirements that have to be met. (Santander Trade Portal, 2015).

In Switzerland SMEs represent 99.6% of the Swiss enterprises and employ 66.6% of the labour force (SECO, 2015). Due to its importance, it is relevant to focus on Switzerland's SMEs policy in order to better understand the general policy environment for business. The objectives set by the SECO with regards to the SMEs policy are defined around the following pillars: Competition policy to stimulate competition within Switzerland; foreign economic policy to strive for economic openness and improved access to foreign markets; labour market policy to maintain high employment rates; education policies to strengthen education, research and innovation; finance policy to ensure sound public finances; legislation to create a legal environment that is conducive to entrepreneurship (SECO, 2013, p. 4).

In order to guarantee the achievement of these goals, the Confederation has designed a number of policies and mechanisms. The SME Forum has been established as an extra-parliamentary expert commission geared toward guaranteeing the interests of SMEs. Its influence and lobbying ability is relatively high when considering that in previous years nearly the 70% of the recommendations coming from the Forum have been implemented (SECO, 2013).

Another instrument within the SME's Policy is the implementation of an e-government service. This platform simplifies a number of bureaucratic processes and eases day-to-day activities. Among its services: Electronic office for start-ups; commercial register, criminal records or debt collection reports; salary statements; trademark registration; economic and financial information and; SuisseID which was launched in 2010 and allows secure electronic business transactions (SECO, 2013, p. 8). Within the SME policy

there are also instruments that allow enterprises access to funds and credits. This section will be further developed in section 5.4. Another service that is embedded within the SMEs' policy is the SERV. This service has been designed to increase security and liquidity for exporters. It aims to reduce risk in international business operations as well as, in the case of need, provide a guarantee for possible debt defaults (SECO, 2013, p. 12).

The SMEs' policy also supports Vocational and Professional Education Training (VPET) and through the SERI, the Swiss VPET activities are coordinated with other countries. In addition, SMEs can benefit from the excellent academic and research environment as well as other federal institutions such as the CTI, which facilitates knowledge transfer processes and entrepreneurship, as will be explained in section 5.7.

5.2 Young innovative companies and start ups

A large part of Switzerland's success in innovation and international business is related to its approach of managing internationalisation processes. Within the SMEs policy, the Switzerland Global Enterprise platform (S-GE) – formerly called Osec – has acquired the government mandate to help businesses to expand their activities abroad as well as promoting imports. The Swiss Business Hubs – 21 across the world – on the other hand are the international S-GE's representations, which act as antennas to facilitate and exchange communication among potential stakeholders (SECO, 2013, p. 14).

Not all the entrepreneurial ventures and start-ups can be defined as innovative. As indicated by the Global Entrepreneurship Monitor (GEM), Switzerland does not show great potential with regard to creating new jobs through new companies (Total Entrepreneurial Activity, TEA), at least in the short term (GEM, 2012). Nevertheless it is important to note how innovativeness and the national innovation capacities (NICs) are measured.

In retrospect, from 1998 to 2000, and from 2006 to 2008, the proportion of innovative industrial companies remained almost constant (67-68%). In contrast, in 2010 this proportion decreased by 10%, most probably due to the effects of the global financial and economic crisis. Yet Switzerland remains second in the ranking right behind Germany (KOF, 2015). The countries that follow in the ranking are the Netherlands, Finland and Sweden. Between 2008 and 2010 the Swiss companies that introduced improved or innovative services fell to 44%. In addition, a stronger CHF negatively affected the export industry and the tourism sector (KOF, 2015).

Nevertheless, in order to fight the effects of the crisis and international competition since 2010, Swiss companies have shown more interest in innovating both in the industrial and services sectors (KOF, 2015). In 2013, a record number of 40,000 new enterprises were created (GEM, 2013).

According to the Swiss Start-Ups Monitor (SSUM), as of 2015 there were 1583 registered start-ups (Swiss Start-Ups Monitor, 2015). The table below shows the registration activities over the 2010-2015 period.

Table 7. Start-Ups creation 2010-2015. Source: SSM, 2015

German speaking part	French speaking part	Italian speaking part
1045	514	27

As the following table shows, the ICTs sector is the most quantitatively dynamic in terms of start-up creation. It is followed by sectors that can traditionally be considered core sectors in Switzerland's economy.

Table 8. Start-ups by sector

ICT	526
Consulting and services	203
Medtech and diagnosis	179
Engineering	174
Biotech and pharma	141
Other	117
Energy and greentech	77
Consumer products	62
Micro-nanotech	34
Sensors and analytics	28
Material sciences	27
Agriculture	8
Chemicals	7

A national innovation system would be incomplete in absence of frameworks and policies stimulating entrepreneurial activities. The CTI has developed strong assets in order to strengthen the position of rising start-ups and entrepreneurial behaviour. The vectors along which CTI accompanies these initiatives are clustered around the following: CTI Start-up; CTI Entrepreneurship and; CTI Invest. According to the CTI Start-up, there is a strong correlation between those enterprises which are labelled CTI and those which are not in terms of long-term survival rate, the capacity to raise funds, job creation and market success (CTI). In this sense public efforts play an important role in strengthening private initiatives. Regionally speaking, and both channelling the efforts promoted by the CTI and/or acting with a certain degree of autonomy, there is a dense network of agencies and platforms encouraging innovative entrepreneurship. Further discussion on this topic can be found in section 5.6.

The CTI Start-up enables entrepreneurs to put into motion their innovative ideas. This support is materialized in three phases that lasts between 6 and 24 months. After the successful completion of the three initial phases, the CTI Start-up guarantees support.

CTI Entrepreneurship (formerly Venturelab) provides courses and training and is mostly divided into members of universities and Start-ups. Members of universities can follow two courses: Business Ideas and Business Concepts, whereas the start-ups can follow courses on: Business Creation and Business Growth (CTI Entrepreneurship). A new stand-alone course on Social Entrepreneurship completes the offer. These courses are offered across Switzerland and they are provided by six different managing groups (Table 10).

Table 9. Course providers and regions. Source: CTI Entrepreneurship.

Provider	Course Location
Start-up Campus	Zürich, Winterthur and St. Gallen
CTI Entrepreneurship Training –Mitte CH	Basel, Bern, Biel, Brugg and Lucerne
CTI Entrepreneurship Training- Western CH	Geneva, Lausanne and Neuchâtel
USI-Supsi, Start-up Centro Formazione	Lugano and Manno
IFJ Start-up Support	St. Gallen, Zürich and Lausanne
Seif-Social Entrepreneurship	Bern and Zürich

Finally, CTI Invest complements the two instruments mentioned above. It was established in 2003 as an independent, not for profit private-public-partnership (PPP). Its objective is to close the financing gap in the first stages of the start-up. Beyond the traditional funding instruments, CTI Invest offers coaching to start-ups. CTI labelled start-ups can enjoy the advantages of a platform where they can present their business ideas to a large audience of business angels and investors, as well as to national and international venture capital firms (CTI Invest, 2015). The diagram below shows this mechanism in detail.

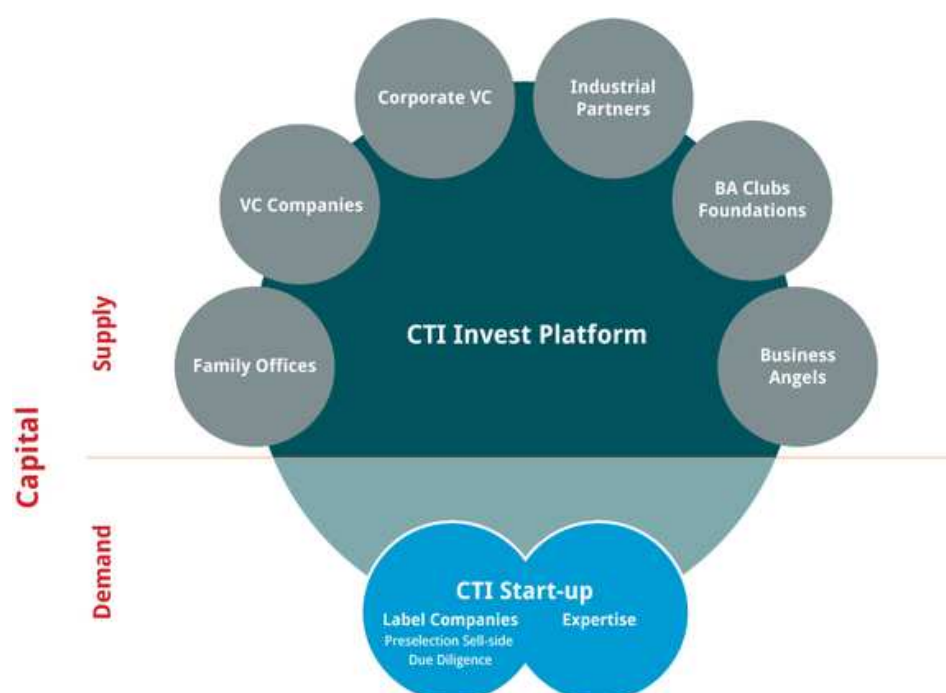


Figure 1. CTI Invest-Functioning. Source: CTI Invest.

Every year both the CTI CEO Day and the Swiss Venture Day are the most important networking and information events in the Swiss entrepreneurial ecosystem. These events allow CTI Invest-supported start-ups to gain access to an influential audience composed by media representatives, CEOs, industrial stakeholders, business angels and venture capitalists. By taking part in these events, young entrepreneurs are helped to pitch their project effectively and to improve their negotiation and communication skills.

5.3 Entrepreneurship skills and stem policy

Switzerland as an innovation driven economy, shows a positive attitude towards entrepreneurially related activities. Fostering and developing entrepreneurship remains high among Switzerland's policy agenda. The GEM 2014 census indicates that the perceived opportunities to start a business were higher in Switzerland than the previous year. Nevertheless this figure is slightly higher: 43.7% against 41.5%. However, this figure is higher than the average for innovation-driven economies, which is 38.8% (GEM, 2014). In contrast, Canada, the US and Scandinavian countries top the ranking.

The overall fear of failure in Switzerland is low (29%), whereas the perception of capabilities remains relatively high (41.6%) (GEM, 2014). This figure is slightly better than the European benchmark, however it remains lower than the US where the overall perception of individual's capabilities is high. In perusing entrepreneurial intentions of Swiss inhabitants, these intentions remain at 7.1%, which is lower than in 2013, the year that recorded the highest registration of new businesses. This result remains far lower than the average for innovation-driven countries (12.3%) (GEM, 2014). The reasons behind this trend will be explained below. The following table summarizes the comparison of entrepreneur-related activities between Switzerland and other innovation driven economies.

Table 10. Comparison of GEM indicators between Switzerland and Innovation driven economies. Source: GEM, 2015.

Variables	2014-CH	Average innovation driven economies	Variables	2014 CH	Average innovation driven economies
Perceived opportunities	43.7	38.8	Total early-stage entrepreneurial activity rate (TEA)	7.1	8.5
Perceived capabilities	41.6	42	Necessity driven (in % of TEA rate)	14.4	37.8
Fear of failure	29	37.8	Improvement driven (in % of TEA rate)	58.1	54.9
Entrepreneurial intentions	7.1	12.3	Nascent entrepreneurship rate	3.4	5.3
Entrepreneurship as a good career choice	42.3	55.1	New business ownership rate	3.8	3.4
Owner manager in established business rate	9.1	6.7			

Beyond the international comparison, it is also relevant to reflect on the differences across linguistic zones in Switzerland. The following table expresses the differences among Swiss language regions related to entrepreneurial attitudes. It is possible to appreciate that both the German and the French speaking regions present a more dynamic attitude towards entrepreneurship than the Italian-speaking portion of Switzerland. The existing economic fabric and dynamic contexts contribute to increasing the propensity towards entrepreneurship. Cities such as Lucerne, Zürich, Basel, Lausanne or Geneva have a clear and long-standing international projection and they are active world players.

They act as economic and political engines and they are highly competitive environments at both the national and international levels. This feature generates a business culture

based on performance and excellence and stimulates entrepreneurial activities. The Swiss Italian region does not have a similar concentration of international cities and therefore the entrepreneurial ferment and fabric is weaker. In addition, the role of the public sector as a preferred employer has been very active in previous decades, which has contributed to a slower path towards a more entrepreneurial culture.

Table 11. Entrepreneurial indicators across Swiss language regions. Source: GEM, 2014.

Variables	CH	D-CH	F-CH	I-CH
Perceived opportunities	43.7	46	38.9	33.4
Perceived capabilities	41.6	42.2	40.4	36.2
Fear of failure	29	26.7	35.8	32.7
Entrepreneurial intentions	7.1	5.6	12.2	2.9
Entrepreneurship as a good career choice	42.3	36.2	58.5	61
High status to successful	65.8	61.1	80.9	61.8

In order to better understand the dimensions of entrepreneurship in Switzerland, it is also important to reflect on how different age cohorts behave. Entrepreneurship activities in Switzerland are very much influenced by age. As the GEM highlighted, youngsters are more prone to explore and propose fresher ideas. However, older people may have gathered sound professional experience that becomes crucial to ensure entrepreneurial success. Generally speaking, the most dynamic and entrepreneurial cohorts are those of 35-44 and 45-54 years (GEM, 2014).

The youngest cohort (18-24 years old) is the least entrepreneurial. Compared to other innovation-driven economies, the TEA rate for the 18-24 cohort is as low as 3.4%, which is at the same time the lowest of all the other studied cohorts where the average amounts to 7.4% (GEM, 2014). It is possible to infer that these results among youth are justified by a lack of self-confidence or because in that age, most youngsters are engaged in undergraduate and graduate studies. These results converge into a two-fold question: Are entrepreneurial incentives and training introduced too late in Switzerland; would it be better to impart an entrepreneurial spirit and innovative behaviour during the compulsory school years? (GEM, 2014).

Entrepreneurial education in Switzerland – like in many other advanced economies in the world – is most likely to occur during the undergraduate education. In this sense, universities, UASs, as well as private institutions offer world-class educations. However, awakening entrepreneurial awareness at earlier stages would represent an adequate measure. In this regard, the Young Enterprise Switzerland (YES) program, part of Junior Achievement Europe (JA Europe) has worked since 2006 to promote entrepreneurial behaviour among youth. Alternative views of teaching entrepreneurship beyond the traditional academic boundaries are also practiced in Switzerland. A branch of the successful Danish Kaos Pilot operates in Bern.

In parallel, consistent Sciences, Technology, Engineering and Mathematics (STEM) policies can reinforce future entrepreneurship behaviour and competitiveness. As a matter of fact, the US Department of Education considers STEM policies to be the cornerstone of future global leadership (US Department of Education, 2015). According to the Australian government, among estimates of STEM publications per country, Switzerland is 11th in the world with 1.4% of the total STEM production globally (Australian Government, 2014, p. 10). However, if this result is weighted per capita, Switzerland tops the world rank. World-class research institutions such as ETH Zurich and EPFL, along with other public and private research institutions are less successful,

which explains Switzerland's efforts to promote a strong STEM education and research policy.

Beyond these comments on STEM policies, it is also important to highlight that the quality of Switzerland's higher education system is firmly underpinned by two factors. First, the education system is characterized by a federal structure. Second, Switzerland gives greater importance to upper-secondary level vocational education and training (VET) and tertiary-level B professional education and training (PET). With regards to VET programmes, most of them are dual-track. This means that host companies pay enrolled students as apprentices, whereas at the same time they receive classroom-based instruction at a VET school. This system equips students with transversal competences such as critical thinking, problem solving, creativity, teamwork as well as communication skills (SER, 2012). This philosophy and *modus operandi* is strengthened by the Universities of Applied Sciences (UASs) (SER, 2012).

5.4 Access to finance

The Swiss financial sector is strong and internationally acknowledged. At the private level, the Swiss banking sector – in all of its forms, also including foreign financing institutions – is strong and provides financing services to entrepreneurs without complicated bureaucratic processes. Innovation parks as well as incubators and regional agencies also have financing services.

The establishment, growth and survival of entrepreneurial ventures is very much linked to the access to finance and the existence of a solid and dynamic financial – public and private – sector. Besides, and considering the economic and entrepreneurial fabric that shall be stimulated, the SMEs – including Start-ups – are probably the most important triggering factor leading to economic growth, productivity, employment, innovation and competitiveness. From 2008 onwards, the global financial and economic crisis challenged SMEs and their capacity to access financial instruments (Ozturk & Mrkaic, FMI, 2015; Wehiger, OECD, 2014). However as the OECD has considered, the Swiss economy has weathered the consequences of the crisis relatively well (OECD, 2015).

As the OECD has highlighted after analysing 28 countries worldwide, Switzerland has been the country which has implemented the lowest number of policies to stimulate access to financing designed to surmount the difficulties generated by the economic crisis between 2008 and 2011. The only measure put forward was to facilitate exports via the increased capital of export support institutions (Wehiger, OECD, 2014, p. 5). This is probably due to the fact that the existing ecosystem of financial mechanisms in Switzerland devoted to meet the needs from SMEs was more efficient and better designed than in other countries. As said above, without implementing new measures, as the OECD points out, both SMEs and total business loans grew during the crisis, although at a much lower pace (OECD, 2012, p. 139). However in 2013, SME business loans grew at a solid rate of 7.3% (in comparison to the 2.8% performed in 2012). In total, between 2007 and 2013, SME loans grew 45.8% (OECD, 2015, 335). In addition, interest rates for loans less than CHF 1 million have consistently decreased since 2009.

In regards to Venture Capital in Switzerland, this market has operated relatively well. Nevertheless seed financing, which is crucial for the creation of new enterprises, is difficult to obtain (Swiss Federal Council, 2012). The following table shows the private equity and Venture Capital investments in the confederation between 2007 and 2013.

Table 12. Private Equity and Venture Capital Investments CH- 2007-2013. Expressed in € thousand. Source: European Private Equity and Venture Capital Association, 2014.

Type	2007	2008	2009	2010	2011	2012	2013
Seed	10,413	17,236	6,105	5,237	6,503	12,631	8,087
Start-up	114,761	95,051	151,839	127,862	160,934	73,173	145,805
Later stage venture	152,011	57,866	67,295	48,637	34,201	95,886	42,406
Growth	56,412	137,657	76,735	213,557	43,373	98,304	36,480
Total Venture Capital	333,597	307,810	301,975	395,294	245,012	279,994	232,777
		-7,7%	-1,9%	30.9%	-38%	14,3%	-16.9%

In considering the public sector, the SECO *per se* cannot directly fund private businesses. However, within the aforementioned SMEs policy and the NRP, the Confederation has implemented, or supports, a number of mechanisms to facilitate access to finance. When entrepreneurs wish to enlarge or develop their businesses, they may use a guarantee. In Switzerland there are three regional guarantee cooperatives (central, eastern and western Switzerland) and one national cooperative specially focusing on women (SAFFA) (SECO, 2013, p. 10). These guarantee cooperatives help promise that SMEs obtain bank loans up to an amount of CHF 500,000. These cooperatives are partially covered by the government. In this sense the federal government covers 65% of the exposure and shares the administration costs (OECD, 2015: 337).

As highlighted in section 5.2, regionally speaking there are a number of services and mechanisms facilitating the access to credit. The CTI itself has channelled through regional agencies the services to encourage start-up creation and to boost entrepreneurship. Beyond these two instruments, CTI Invest has been the leading financing platform in Switzerland since 2003. Since then, its financing volume for early-stage companies has reached an accumulated value of CHF 550 million (CTI-invest 2015). The role of business angels in Switzerland is important. Business Angels Switzerland (BAS) is the leading organization of its kind. The association is made up of 86 members and was formed in 1997. Currently it is a member of CTI Invest and the Swiss Private Equity and Corporate Finance Association (SECA). They are split into two sections: the Swiss German section, headquartered in Zürich and the Suisse French section based in Lausanne (BAS, 2015). It is important to note that the Swiss Italian region is not integrated.

Investments are made by individuals, not by the association. Typically it is possible to say that the most common, consolidated, investment fluctuates between CHF 100,000 and CHF 250,000 (BAS, 2015). Since 1997, BAS has facilitated investments for 100 start-ups. The StartAngels Network, which was established in 2000, follows the same rationale and philosophy by funding promising initiatives with funds between CHF 50,000 and CHF 200,000 (Startangels, 2015). The table below shows a more detailed picture of the CTI invest ecosystem.

Table 13. Investors. Source: CTI Invest 2015.

Type	Number
Institutional investors CH	28
Institutional investors-foreign	9
Industrial partners	16
Business Angels Club	9
Business Angels	21
Family office	6
Facilitators	2

Another important platform supported by private foundations such as the Gerber R f Stiftung and Avina is Venture Kick. Since 2007, the organisation has helped 403 start-ups and has raised more than CHF 896 million (Venture Kick, 2015).

With regards to crowdfunding, it is possible to say that this alternative financing system is not yet very developed in Switzerland, although the growth figures may appear spectacular. Between 2013 and 2014 the growth rate has been 36%: From nearly CHF 12 million to CHF 16 million (Crowdfunding Monitor Switzerland, 2015). The first crowdfunding platform in Switzerland was Cashare and was established in 2008. Currently there are 30 active platforms providing these services. The following table shows the top five sectors in 2014.

Table 14. Crowdfunding 2014-top five. Source: Crowdfunding Monitor Switzerland, 2015.

Ranking	Category	Total campaign CHF generated	Number of Projects	Average campaign CHF generated
1	Music, concerts and festivals	1,472.267	216	6,844
2	Technology, business and start-ups	1,465.555	40	36,639
3	Society, social projects	1,338.418	131	10,217
4	Sports and health	733,330	128	5,729
5	Film, video	512,853	71	7,223

5.5 R&D Related FDI

As Hotz-Hart recognised in 2007, the success of the Swiss Innovation System depends on the interaction of three factors: Economy, education-R&D and policies within a process of rising internationalization (Hotz-Hart, 2007). A harmonized balance among these three factors would strengthen Switzerland's leading position as a competitive and innovative economy.

It is not possible to consider a precise figure on R&D related to FDI, however it is possible to approach this gap by considering the breakdown of FDI in sectors – both inflows and outflows – and afterwards, by extrapolating the results. According to the Swiss National Bank (SNB), Swiss direct investment abroad (outflows) has curved

systematically since 2010. However, the EU remains the most important geographical region where these investments are allocated, with CHF 12065 million.

Table 15. FDI Outflows. Source: SNB, 2015. In CHF million

2009	2010	2011	2012	2013
28703	89378	42755	40622	31508

The figures represented in the table below show the breakdown of the most relevant economic sectors of Switzerland's outflows. The pink-shaded components/sectors, manufacturing, are those which mainly concentrate and entail R&D activities.⁴ For 2013 they represent 35.6% of all outflows. This result is definitely negative, nearly halved when compared with the 2011-2012 period.

Table 16. FDI Outflows/Economic Sectors. Source: SNB, 2015. In CHF million

Sector	2009	2010	2011	2012	2013
Manufacturing	10495	7283	22681	18363	11244
Textiles & Clothing	-3145	-7134	115	-1785	970
Chemicals and Plastics	1632	-1855	15881	9386	3073
Metals and Machinery	374	-248	-8069	3453	1656
Electronics, Energy, optical and Watchmaking	6384	9364	5082	3108	5346
Other manufacturing and construction	5250	7156	9672	4201	200
Services	18209	82095	20074	22259	20264
Trade	11617	13062	7814	3299	1960
Finance and Holding co.s	-5726	49057	-2931	6591	-1174
Banks	3310	4535	1405	5187	13320
Insurance Co.s	6374	13306	11701	4584	4691
Transportation and Communications	214	500	539	1020	1019
Other services	2421	1635	1546	1579	448
Total	28703	89378	42755	40622	31508

With regards to the inflows, the figures presented in the table below show that their evolution is similar to the FDI outflows. However in this case, the withdrawal of funds coming from abroad has sharply shrunk in comparison to the preceding years. One reason may be that the issues related to bank secrecy, as well as the millionaire fines imposed on some major Swiss banks, have generated a negative image.

⁴ Considering the composition of R&D activity branches proposed by the FSO.

Table 17. FDI inflows. Source: SNB, 2015.

Sector	2009	2010	2011	2012	2013
Manufacturing	95.3	-933	-6798	4543	6922
Chemicals and Plastics	2883	2535	1626	351	3100
Metals and Machinery	754	-261	-7645	909	376
Electronics, Energy, Optical and Watchmaking	3972	-1588	-699	3240	3370
Other manufacturing and construction	1894	-1620	-80	44	77
Services	21935	30911	31938	10449	-6312
Trade	4139	10871	11361	14248	1045
Finances and Holding Co.s	15793	18309	21276	-7810	-4869
Banks	2287	311	849	-782	-3150
Insurance Co.s	1288	1299	-1365	-56	353
Transportation and Communications	-521	-33	348	6226	-5
Other Services	-1051	155	-532	-1377	314
Total	31437	29978	25140	14993	610

With regards to the FDI, outflows, both the Confederation and the cantons are actively involved. On the one hand the Confederation and the cantons fund 25% of all national R&D activities. Beyond the traditional FDI formulas and focusing on the international commitment to support R&D activities, the Confederation invested CHF 730 million in 2012. This amount was released to support R&D programs with the EU (FRP), the European Space Agency (ESA) and CERN (KOF, 2013. p. 15).

In reviewing the FDI, inflows, in 2012 international stakeholders invested as much as CHF 2,200 million in Switzerland for R&D collaborations and projects. This figure equals 12.1% of Switzerland's total expenditure in R&D. Nearly CHF 2 billion were invested in the private sector through the allocation of specific mandates. As a rule of thumb, most of the beneficiaries of these funds were the domestic branches of the same foreign companies (KOF 2013. p. 15).

5.6 Knowledge markets

One of the most important factors underpinning innovation policies and processes is the protection of intellectual property rights (IPR) (Thumm, 2000). Without a consistent and strong policy focusing on the protection of these rights, the entire "innovation" building and system – as well as the existing knowledge markets and the country's competitiveness – would be jeopardised (Alikhan & Hashelkar, 2004). At the EU level, at the end of 2011, all member-states and stakeholders put forward a proposal to develop a European knowledge market for patents and licensing (Innovation Union, 2011).

Switzerland has a extensive experience in IPR related activities. The Swiss Federal Institute of Intellectual Property (IGE/IPI) – which is an autonomous entity – was founded in 1888. In 1996 it received its current status as an organization incorporated under public law (IPI, 2015). The IPI oversees activities related to patents, copyrights, trademarking, design, etc. So far Switzerland has signed 12 bilateral agreements on IPR (IPI, 2015). The IPR and overall legal system in Switzerland is sophisticated and strong. IPR entails general as well as specific protection mechanisms, and is backed by civil and criminal law (IPI, 2015).

According to the European Patent Office (EPO), Switzerland is number one in the world concerning patents per capita (847.6 new patents), followed by Finland (416.2) and the Netherlands (405.5) (EPO, 2015). The most active companies filing new patents were ABB, Nestlé, Roche and Novartis. Putting aside these multinational corporations (MNCs),

public research institutions such as ETH ZÜRICH, EPFL and the University of Zürich are among the top 25 patent filers in the nation (Switzerland Global Enterprise, 2015).

These institutional and legal frameworks contribute to the proper development of efficient and dynamic knowledge markets. Knowledge markets normally are not centralized places and they enhance communication among participants in order to search for efficient solutions to common problems. Moreover, they are spaces where new and innovative ideas and new approaches can be discussed, rehearsed and implemented.

One of the most notable on going experiences in this regard is the development of a decentralised Swiss Innovation Park (SIP). In 2012 the Swiss parliament approved a complete revision of the RIPA act. One of the purposes was related to the creation of the needed legal framework, which would allow the allocation of funds for a Swiss Innovation Park. This initiative is steered by the Swiss Innovation Park Foundation, which was established in March 2015 as the umbrella institution. In summer 2014, the Federal Council approved the decentralised configuration put forward by the Conference of Cantonal Directors of Economic Affairs (VDK).

In reviewing this proposal it is possible to see that despite its decentralised nature, organisationally and operationally speaking, the SIPs would be headed by the two federal institutes of technology. Moreover, the different branches have been located within the most dynamic economic, industrial, educational and political centres in the confederation with the purpose of optimising and maximising existing resources. The five SIP centres are: SIP Park innovAARE (Argau); SIP NWCH (Basel and Jura); SIP Bienne; SIP West EPFL (Vaud) and SIP Zürich ETH ZÜRICH (Zürich).

The SIP embraces the same philosophy that has characterized the Swiss Innovation System so far. That is, the converging efforts of the Federal government, the cantons as well as industries and educational and scientific institutions. The SIP will offer research-intensive companies the best possible environment to boost their innovation processes while allowing them to enter into the national and international market by contributing towards the strengthening of the leading position of Switzerland as it pertains to competitiveness and innovation.

The SIP culminates an important phase of fine-tuning for the Swiss Innovation System and paves the way for future coordinated initiatives. Another planned benefit of this policy is related to the fact that the SIP entails a strong regional focus too. With that being said, instead of underpinning existing research-intensive industries, science will also contribute positively to the development of the regional fabric of Small and Medium Enterprises (SMES). This also means that the SIP will also be embedded and contribute to the existing New Regional Policies (NRP), as well as cantonal policies addressing and bolstering innovation.

5.7 Knowledge transfer and open innovation

One of the pillars guaranteeing the success of the Swiss Innovation System is the existence of a strong *de facto* public-private research partnership. The interaction between universities and the industrial sectors facilitates the discovery of new opportunities and fosters innovation (David, 1998; Foray, 2007). One of the earliest studies on this topic reveals that the cooperation between industries and educational-research institutions was very low according to author's opinion (Arvanitis, Hollenstein and Marmet, 2006). The table below shows the main knowledge transfer mechanisms as well as their nature. Most of the cooperation and transfer was operated through informal mechanisms.

Table 18. KTT activities. Source: Arvanitis, Hollenstein & Marmet, 2005.

Knowledge and technology transfer activities	Knowledge and technology transfer active firms reporting 4-5 on a 5 point Likert scale %
Informal	56.6
Contacts	30.4
Conference	30.4
Publications	33.1
Technical infrastructure	11.9
Common lab	3.9
Use of university technical infrastructure	10.7
Education	52.3
Employment of graduates in R&D (plus contracts)	28.5
Student's participation in firm R&D	10.9
Joint diploma theses or joint PhDs	22.7
University researcher participation in firm	10.1
Enrolment in university training course	22.1
Research	17.8
Joint R&D projects	16.3
Long-term research contracts	54.1
Research consortium	4.1
Consulting	15.3

Since 2006 this panorama has evolved and improved. As it was explained in the previous section, the evolving entrepreneurial and innovation environment in Switzerland greatly facilitates the exchange of knowledge and information among stakeholders, even if many times they follow informal patterns.

Beyond this outstanding effort, in Switzerland there is a very dynamic innovative fabric that operates internationally, regionally and inter-cantonally through a number of platforms and initiatives. The following table aggregates some of the most representative examples of platforms.⁵

⁵ For a full list of institutions and platforms – mostly technology parks and incubator centres- – encouraging entrepreneurial activities and innovation see: OSEC (2012): *Handbook for Investors. Business Location Switzerland*. Available at: https://www.vs.ch/NavigData/DS_346/M26934/fr/pub_handbuch_invest_ae.pdf (Last retrieve, 19th October 2015)

Table 19. Innovation platforms and agencies. Non exhaustive sample. Designed by the authors

Cantonal	Inter-cantonal	International
<ul style="list-style-type: none"> -Agire -Impact Hub Zurich -Friup-Fribourg -Regional Development and Economic Promotion-Agencies -Venturelab -Swiss Creative Center- Neuchatel -Innovation GR-Graubünden -Foundation for Innovation, Development and Research-Graubünden -Technology Cluster Zug -ITS Industrie and Technozentrum Schaffhausen -Cantonal Vocational and Professional Education and Training (VPET) -UASs -Universities and Research Centres 	<ul style="list-style-type: none"> -Genilem-Vaud and Geneve -Platin -Alliance -YES-Young Enterprise Switzerland -Creapole -i-net innovation networks-Northwestern Switzerland -SIP -invention.ch -Le Reseau -UASs -Universities and Research Centres 	<ul style="list-style-type: none"> -SIP -Sino-Swiss Innovation Centre -Swiss-Swedish -SwissCore-CH-EU education and research -Swissnex -Swiss Business Hubs (21 worldwide) -UASs -Universities and Research Centres

The Swiss Technology Transfer Association (SWITT) was founded in 2003 and is the main association of technology transfer professionals who are active in the country. The members belong to institutes of public research and education, university hospitals, as well as not-for-profit organizations (SWITT, 2015). Beyond that, the most representative Swiss universities have established their Knowledge and Technology Transfer offices.

In Switzerland the Swiss Knowledge Management Forum (SKMF) also exists. It is the leading platform in the Confederation, which aggregates national and international experts on knowledge management related activities. With regards to innovation, it is also relevant to mention the Swiss Innovation Forum (SIF).

The proportion of innovative enterprises that have developed certain sorts of cooperation with UASs or research centres has amounted to 16% between 2006 and 2008. This figure implies that Switzerland remains aligned with Germany (14%) and Sweden (14%). However, other countries such as Austria and the Netherlands present values around the 30% and 22% respectively (KOF, 2015).

Speaking about formalised cooperation, one-fifth of Switzerland's enterprises are associated with Knowledge Transfer related activities. This situation has remained practically unaltered since 2000. Within this figure the proportion of industrial companies involved in processes of KT have been higher (28%) than services companies (25%). Nevertheless, despite this stability, the higher growth rate has been experienced within the high-tech sector. Another relevant aspect is the size of those companies participating in KTT processes. According to the figures released by the KOF, 16% were small companies; 35% were medium enterprises and 57% were large corporations (KOF, 2015).

In reviewing the nature of KTT related activities, most companies have acknowledged that beyond the majority of informal relations, 17% requested research services, 15% technical advice and 14% indicated that they benefited from the usage of university facilities (KOF, 2015). 70% of companies engaging with any type of KTT activities declared that they worked along with the Federal Institutes of Technology (FIT: EPFL and ETH ZURICH) between 2008 and 2010 (ETH Board, 2011). Additionally 68% established a collaboration with UASs and 43% worked together with cantonal universities (KOF, 2015). It is also important to mention that KTT activities encountered some hurdles. Some companies perceived that in developing KTT projects along with UASs, the

institutional and organizational obstacles, including bureaucratization, increased from 2002 onwards.

The CTI is considered the umbrella institution as well as decision-making body in charge of backing and promoting innovation processes between research institutions and the industry. Its role is crucial in establishing networks of a different nature: cantonal, national and international. The CTI funds four areas: R&D project grants; start-up and entrepreneurship; KTT support and Energy funding programmes. It works along three main axes: Innovation mentors; National Thematic Networks (NTNs) and promotional events. Notably there are eight NTNs: Carbon Composites Switzerland; Inartis; Innovative Surfaces; Swiss Biotech; Swiss Food Research; Swiss Wood Innovation Network; Swissphotonics and; Verein Netzwerk Logistik. These NTNs are especially relevant for local SMEs, which need scientific and knowledge revamping strategies, therefore they contribute in a greater manner to the development of cantonal economic-entrepreneurial fabrics as well as having a decisive impact in underpinning cantonal policies on innovation and economic promotion. Beyond that, the NTNs are also active in propelling Swiss SMEs abroad through the implementation of programmes of internationalization.

With regards to open innovation, some private companies have publicly declared their commitment to embark in open innovation practices. For instance Swisscom has created the label NOVA and through it the company states that it wants to develop new ideas and products along with interested consumers as early as possible (Swisscom, 2015). This participatory and open approach – which is also followed by other companies and is surely a common informal practice disseminated in innovation parks and incubators, is twofold: On the one hand it may benefit from the experiential and technical knowledge of users, on the other hand it increases the company's image of transparency and involvement with consumer's needs and expectations. Swiss Post has followed a similar approach throughout the creation of the Development and Innovation Office (Swiss Post, 2016).

In Switzerland there are 25 important open innovation platforms (SISRE, 2015). As mentioned before, university offices of Knowledge and Technology Transfer participate actively as platforms promoting open innovation. A favourable environment supporting knowledge transfer and open innovation between academia and the private sector is clearly present. However more can be done. PhD positions are mostly linked to universities, whereas some other countries that are leaders in innovation, such as Denmark, Norway or Finland also offer industrial PhDs. In this regard, the European Union has also developed the European Industrial Doctorates (EID), which are geared towards covering the gap between academia and the real needs of the industrial sector (European Commission, 2016).

5.8 Regulation and innovation

According to the Oslo handbook the four fronts which should be developed to ensure the implementation of sustainable and coherent innovation processes and policies are: Framework conditions, science and engineering base, transfer factors and the innovation dynamo (OECD, 2005). Switzerland has shown awareness in this regard and since the 1990s efforts to harmonize the aforementioned fronts have increased. As previously explained, at federal the level innovation policies are shared by a number of departments and agencies. It is possible to subdivide the Swiss innovation policy into two main blocks. The first considers innovation broadly and generates optimal economic frameworks to better implement financial and politico-economic policies. The second focuses on developing specific mechanisms and instruments conducive to improve innovation promotion, education and research (Alberton et al. 2011).

In considering the second block, the main federal departments involved in promoting innovation are:

- Federal Department of Home Affairs (FDHA)

- State Secretariat for Education, Research and Innovation (SERI)
- Federal Department of Economic Affairs, Education and Research (EAER)

On the other hand, the main agencies promoting innovation and research are:

- Swiss National Science Foundation (SNF)
- Commission for Technology and Innovation (CTI)

Therefore the Swiss Innovation System (SIS) can be subdivided into federal and regional-cantonal efforts, policies and mechanisms. The SIS ultimately aims to develop cantonal and inter-cantonal networks in order to foster regional development and competitiveness. In addition, the SIS is founded upon the principle of integrating and harmonizing the triple helix (academia, industry and government). In this sense the cantonal and inter-cantonal initiatives to promote co-operation are guided and steered by the New Regional Policy (NRP), which began in 2008. There are also specific cantonal efforts in codifying innovation policies. In 1997 the canton of Ticino released the first law of economic innovation, which was revised and adapted in 2015 (Alberton & Huber, 2014).

Operationally speaking the Federal Government is responsible for the definition, implementation and monitoring of national research and innovation policies (Switzerland Country Profile EU, 2013). These actions are conducted through a number of agencies. The Swiss parliament established the Commission on Science Education and Culture (CSEC) (Swiss Parliament, 2015). This committee is in charge of discussing crucial issues of science and innovation policy. It also deliberates on issues such as draft laws and motions as well as preparing plenary decisions (Swiss Country Profile, EU, 2013). In considering the whole ecosystem of the SIS – including public and private stakeholders as well as civil society – it is possible to conclude that it is a highly participative system. The discussions, design, implementation and evaluation of innovation policies are highly shared.

Since 1990, the KOF has been conducting an innovation survey every three years on behalf of the Federal Department of Economic Affairs (SECO). Methodologically speaking 6,500 companies are selected to complete a questionnaire. This questionnaire is divided into five different categories: Innovative capacity, networks of knowledge, objectives of the innovative activities, obstacles to innovation and innovation promotion (SECO, 2016). By gathering this data it is possible to first assess the levels of innovation capability (descriptive analysis), then to extract valuable conclusions for economic policy (normative analysis), and finally, to explain how innovation processes work (explicative analysis) (KOF, 2016).

For its contribution, the Swiss Science and Innovation Council (SSIC) produces and commissions a number of studies that assess crucial aspects related to the impact and outcomes of innovation policies. Although the SSIC has an independent role as an advisory body, its influence is elevated. Some of the latest titles dealing with these issues are listed in Table 21.

Table 20. SSIC publications in 2015. Source: www.swir.ch.

An Inventory of Swiss Innovation Policies
Measuring Innovation
Open access: Publishing, Commerce and the Scientific Ethos (2015)
Innovation and Public Promotion of Innovation (2015)
Systematic impact evaluation of National Centres of Competence in Research from 2001 to 2013 (2015)
Dr. Unemployed? The professional success of PhD graduates in Switzerland (2015)
Evaluating the Swiss National Science Foundation with Respect to the Strategic Funding on Research Infrastructures and Disciplinary Areas (2015)
From Science Council to Innovation Council (2015)
PhD Cultures and Tenure Track Models at Swiss Universities
Trends in Biomedical Research

The first two documents are especially important. The first document is probably the first attempt to map all federal and cantonal initiatives related to innovation policies. In total there are 142 innovation policy initiatives presented (Good & Ohler 2015). In considering this first mapping, it is possible to extrapolate three possible conclusions. First, federal policies are much better known than cantonal policies. Second, in order to understand how any innovation system works, it is not enough to analyse just the main policies emanating from the central administration. It is also crucial to know and to understand cantonal, regional and sub-regional initiatives aiming at promoting innovation. Second, it's important to know how these two dimensions interact together. Third, it would be necessary to know whether or not a vast policy-ecosystem contributes to achieving higher degrees of success or not. In any case, the monitoring and evaluation system should be better defined and designed in order to grasp those relevant factors that are crucial to understanding this complex scenario at all levels.

Therefore, it is clear that Switzerland has begun to make a serious effort in implementing the right methodologies to know and understand how innovation processes and policies work or should work. As it was commented earlier, the canton of Ticino has developed concrete studies to understand how the innovation system works by identifying specific indicators and metrics. After that, the nLInn (new law for economic innovation) was discussed and approved in 2015 (Alberton & Huber 2014). These efforts should be generalised at the federal level.

5.9 Assessment of the framework conditions for business R&I

It is important to briefly embed this assessment into a theoretical frame. The concept of a National Innovation System (NIS) was initially coined in the 1980s (Freeman & Lundvall, 1980). Today it is widely accepted as a concept. As Marxt and Brunner highlight, the common consensus assumes that NISs integrate organizations and institutions searching and developing a culture of innovation as well as its dissemination and diffusion (Marxt & Brunner, 2013, p. 1035). In addition, R&D-I efforts developed by business ventures, public stakeholders, learning processes, incentive mechanisms, policies and platforms as well as the existence of an adequate skilled labour force to integrate this approach.

Therefore as Marxt and Brunner have defined, this approach is "based on a systemic approach rather than a linear push and pull processes" (Marxt & Brunner, 2013). Therefore, this approach has mutated from initiatives promoting science and technology policies towards examples of innovation policy/ies (Lundvall & Borrás, 2005). The concept of innovation policy/ies entails the aforementioned systemic approach. As a matter of fact, this systemic approach is grounded in the presumption that innovation processes cannot be split and decomposed into a number of isolated and autonomous

phases or stages following a predefined linear script (Samara, Georgiadis and Bakouros, 2012, p. 624).

These comments are relevant to better analyse and assess the framework conditions for business R&I in Switzerland. Initially the existence of a so-called Swiss Innovation System (SIS) was accepted. Nevertheless, there are some authors that consider that even by 2004 it was not possible to consider the existence of such a system because innovation policies and frames were not consistent and integrated (Berwert et al., 2004). Therefore the SIS, instead of being considered as systemic, was predominantly defined as a linear push and pull process.

Over the years the confederation has progressed towards greater consistency in this regard. The promotion of scientific research and innovation has been guaranteed by Art. 64 of the Swiss Federal Constitution since 2006. The following table describes the SWOT analysis of the SIS.

Table 21. SWOT analysis of the Swiss Innovation System. Source: Marx, C. and Brunner, C. 2011, p. 7. Modified by the author (*italics*).

Strengths	Weaknesses
Top ranks in research	No coherent innovation policy and according instruments for the implementation of results of scientific research in products
Top ranks in innovative performance	Societal climate for innovation
High R&D spending of private sector	Data quality
High number of employees in knowledge intensive services	Surrounding conditions and opportunities for financing of start-ups and spin-offs
Very good infrastructure	Amounts of funding for innovation
Opportunities	Threats
Simplify and strengthen of universities and business	Changes in the macroeconomic surrounding (e.g. economic cycle; global competition)
Establishment of centres for innovation	Intensification of competitive regulation (e.g. worsening of fiscal situation for business)
Promotion of non-technical innovation	<i>Monetary policies (challenging ex-imp activities)</i>
Further development of (continuing) education	<i>Political and diplomatic relations with the EU</i>
Sustainable and coordinated communication of Switzerland as place for innovation	
Export of knowledge intensive services	

Both the strengths and opportunities summarized in the SWOT analysis have been detailed in preceding sections. Since this analysis was published in 2011, it is possible to say that the Confederation has been very active in promoting networks and centres for innovation, culminated with the launch of the SIP.

However in analysing the SIS it is possible to mention other difficulties that may be obstacles to the achievement of an integrated federal innovation approach. As the OECD has noted, barriers exist for inter-cantonal co-operation for innovation promotion. Most notably these problems are related to: Sharing information on actions; exchanging on methods and building joint tools; developing cooperation projects; and implementing joint activities funded on multi-cantonal basis (OECD, 2011, p. 135). The OECD also mentions that some of the hurdles limiting inter-cantonal co-operation are due to existing inter-cantonal competition. This reality affects the implementation processes of the NRP.

The German Institute for Economic Research (DIW) considered that beyond the Swiss strength for innovation, the Confederation did not achieve effective results in considering social factors (DIW, 2011). In accepting the importance of the innovation systemic approach, socio-political and cultural components –social climate for innovation – are

crucial to ensuring a sustainable model of innovation. Some components of this approach are, among others: A willingness of the people to undertake entrepreneurial risks; the degree of openness and tolerance; a positive attitude towards the participation of women; a positive attitude towards science and technology; and trust in innovation actors (Marxt and Brunner, 2013). The overall ranking displays that Switzerland is 13th out of 17 countries analysed.

The European Commission's Innovation Union Scoreboard shows that Switzerland by far surpasses the EU in innovation.

However as EuroActiv Germany said, it is uncertain how long the country can hold its top spot as the country continues to seek distance from the EU (EuroActiv Germany, 2014). In considering this framework Swiss-EU political and diplomatic relations remains a cornerstone to guaranteeing Switzerland's place in the consistent implementation of innovation policies, as well as ensuring its international competitiveness and attractiveness.

In that sense, the past two years have been difficult, mainly due to two reasons. First, in January 2015 the Swiss National Bank decided to discontinue the minimum exchange rate. Second, in February 2014 the referendum against mass immigration was successful. Whereas the first event generated fear in the private sector, claiming Swiss companies would be less competitive in international markets, the second complicated diplomatic relations between Switzerland and the EU. As far as the first event, the consequences of such a decision have not been as negative as previously forecasted. As for the second, research programmes and joint activities are at stake and their solution results are crucial for Switzerland's future.

In any case, the Swiss economic and industrial fabric remains competitive and innovative. In Switzerland the mix of supply/demand-side policies has improved over the years, which has contributed to strengthening the innovation system, which is able to deal with both internal and external challenges. In 2006 the OECD mentioned that public support for R&D activities was nearly exclusively applied through supply-side instruments. Among them, sophisticated forms of subsidies to universities and UASs in order to help firms have been largely applied. On the other hand, demand-side policies were mostly restricted to new technology-based firms (NTBFs) (OECD 2006: 100). Since 2006, as it has been explained throughout the document, Switzerland has worked towards the establishment of synergies between supply and demand-side policies.

6. Conclusions

6.1 Structural challenges of the national R&I system

Switzerland has an excellent R&I system that is one of the best internationally, both in science and in innovation. This system is based on a strong complementarity between public policies oriented towards basic science and training of human resources on the one hand, and a private sector strongly oriented towards economic innovation and characterized by highly R&D intensive sectors and companies (particularly multinational companies in pharmaceutical, chemical and machine industry). The Swiss economy also comprises a large number of innovative SMEs focused on high-tech and strongly export-oriented markets.

The main challenges to the Swiss R&I are rooted more in the general economic and political context of the country than from the functioning of the system itself:

- A general challenge is maintaining the competitiveness of the Swiss economy in a wealthy country with high wages and general costs, when faced with the competition from countries with a high level of innovation and lower costs. This challenge has been emphasized by the strong appreciation of the national currency in the last five years – the exchange rate EUR/CHF moved down from 1.5 in 2010 to the current 1.1 level. Until now, the Swiss economy weathered the situation reasonably well thanks in part to the intervention of the Swiss National Bank, even if some sectors, like tourism, suffered more.
- There are related challenges concerning the risks of delocalization of important companies, particularly from R&D intensive multi-national companies. Despite the tendency towards globalization of corporate R&D, Switzerland managed to keep, to a large extent, the headquarters and R&D departments of these companies in the country thanks to an excellent infrastructure, good fiscal conditions, and the quality of human resources and of the university system. The major uncertainty in this respect is related to the change in immigration laws and the difficult relationship with the European Union, since the availability of skilled labour and access to the EU space are critical for large companies.
- A key challenge for the Swiss economy and the R&I system is represented by the revision of the tax regime for foreign companies in Switzerland. Until now, most Swiss cantons guaranteed foreign companies individual ad hoc fiscal system, which were more favourable with respect to domestic companies in order to keep them in the country; this practice is no longer acceptable and does not comply with international standards.
- The most important challenge for the Swiss R&I system however is represented by future relationships between Switzerland and the European Union. While this issue has already been debated – with the Swiss population disagreeing with stronger integration and the European Union pushing for a wide-reaching institutional agreement, the situation has become even more complex with the acceptance of the immigration initiative, whose implementation might require renegotiating the bilateral agreements with the European Union (see section 1.1). The acceptance of the initiative already brought negative effects on research cooperation, with the partial exclusion of Switzerland from Horizon 2020 and from the Erasmus plus program (see section 4.2).

A major challenge in this respect is represented by the availability of skilled labour. Since the Second World War, the Swiss economy has been dependent on the inflow of labour from abroad and, particularly for technical professions and highly skilled workers, there is a shortage of domestic manpower. The reintroduction of a quota system for foreign workers foreseen by the constitutional article accepted in 2014 might make the hiring of skilled labour from abroad a more complex process; it also is currently not clear

which balance will be set between the needs of different economic sectors (for example tourism vs. manufacturing industry) in this respect.

6.2 Meeting structural challenges

As highlighted above, the main challenges for the Swiss R&I system are of a systemic nature and depend on how a number of general policy issues will be addressed in the next few years, particularly concerning the relationships with the European Union. The relationship with the EU has always been characterized by a strong ambivalence between the Swiss position in the core of Europe (and a very open country internationally) and the wish to keep the independence of the country and its specificities. Until 2014, the Swiss political system managed to find pragmatic ways to develop relationships with the EU, whose main success was the set of bilateral agreements with the EU signed in 2000. However, the last decade has been characterized by increasing polarization in the political system and mounting success of right-wing parties, who oppose closer relationships with the EU. The (surprising) referendum result of 2014 was largely an outcome of this polarization process and it is not straightforward that pragmatic solutions will be found in the near future.

On the contrary, sectorial policies have been quite successful in addressing emerging challenges for the R&I system. Against the backdrop of high political and financial stability, which has guaranteed increasing resources to the public research system, a number of important reforms have been realised in the last two decades to address some weak points in the Swiss R&I system. Particularly, the creation of the Universities of Applied Sciences, which was highly successful in increasing the provision of skilled labour and reinforcing knowledge transfer towards SMEs. In the public sector, the new higher education act has introduced some coordinating elements in a system whose strength has historically been characterized by a high level of decentralization and regional rooting. In general, the system of strategic plans introduced around 2000 has proven to be effective in achieving a high level of security and predictability of the Swiss R&I policy. The participative approach of Swiss policy, while it might slow down in many cases the reform process, has usually ensured an effective and smooth implementation of policy reforms and measures.

As a witness to this favourable assessment of the sectorial policy, the strategy for the 2017-2020 period largely builds on continuity with the past, while at the same time addressing a few specific challenges concerning professional education, academic careers and innovation (see also section 2.5).

Table 22. Main structural challenges and policy responses

Challenge	Description	Policy response
Maintaining competitiveness of the Swiss economy	Related to the high level of production costs in Switzerland and appreciation of the Swiss Franc. Revision of the tax regimes would imply less privileged taxation for foreign companies.	Keeping good conditions for companies, particularly through administrative simplification. Ad hoc measures from the Swiss Innovation Agency to foster collaborative R&D and innovation in SMEs. Revision of the fiscal regime: reduction of the taxes for all companies and measures in favour of innovative companies (patent box). Reform of the Swiss Innovation Agency.
Delocalization of private R&D	Multinational companies located in Switzerland might delocalize their R&D in more favourable locations or nearer to their main markets.	Providing good conditions for R&D locations of companies. Reforming the fiscal regime to favour innovative companies (patent box model). Keeping an excellent level of the science base.
Access to the European market and European research programs	The foresee quota regulation for immigration could lead to the exclusion of Switzerland.	Search for compromising solutions with the EU. National compensatory measures for participation to H2020 and Erasmus+.
Availability of skilled labour and talented research	High dependency from abroad; new quota system might make hiring of foreign labour and researchers more complex and costly.	Measures to strengthen professional education, education in specific domains (clinical medicine) and to increase the number of students in science and technology. Political lobbying of economic associations and research organizations to take into account their needs in the new regulation of immigration.

7. Annexes

Annex 1 - Abbreviations

CTI	Swiss Innovation Agency
ETH-RAT	Council of the Federal Institutes of Technology
EU	European Union
FIT	Federal Institutes of Technology
GBARD	Gross Budgetary Appropriations for R&D
GDP	Gross Domestic Product
HEI	Higher Education Institutions
OECD	Organization for Economic Cooperation and Development
R&I	Research and Innovation
RIS	Research infrastructures
SECO	State Secretariate for Economy
SERI	State Secretariate for Research and Innovation
SFSO	Swiss Federal Statistical Office
SME	Small and Medium Enterprises
SNF	Swiss National Science Foundation
SSIC	Swiss Science and Innovation Council
SUC	Swiss University Conference
UASs	Universities of Applied Sciences
VET	Vocational Education and Training
PREF	Public Funding of Research Project
SSIC	Science and Innovation Council

*Source: Scimago Institutional Ranking Global 2013.

Annex 2 - List of the main research performers

The following list is based on number of publications. In terms of R&D expenditures, five Swiss companies are among the first 100 companies in the world for volume of total R&D expenditures, i.e. Novartis (5), Roche (7), Nestlé (73), ABB (99) and Syngenta (100; source EU R&D scoreboard; <http://iri.jrc.ec.europa.eu/scoreboard15.html>).

Name	Location	Sector	Publications 2013*	Rank*
Swiss Federal Institute of Technology	Zurich	University	25228	72
Ecole Polytechnique Federale de Lausanne	Lausanne	University	16268	174
Universitat Zurich	Zurich	University	14713	199
Universitat Bern	Bern	University	10801	307
Universite de Geneve	Geneva	University	10249	334
Universitat Basel	Basel	University	7159	493
Universite de Lausanne	Lausanne	University	6771	529
Universitatsspital Zurich	Zurich	Hospital	6725	534
Hopitaux Universitaires de Geneve	Geneva	Hospital	6694	537
Centre Hospitalier Universitaire Vaudois	Lausanne	Hospital	5798	617
Paul Scherrer Institut	Villigen	PRO	4972	711
European Organization for Nuclear Research (CERN)	Geneva	International organization	4849	728
Universitatsspital Basel	Basel	Hospital	4384	797
University Hospital of Bern	Bern	Hospital	3830	897
World Health Organization Switzerland	Geneva	International organization	3066	1080
Eidgenossische Materialprüfungs-und Forschungsanstalt	Dübendorf	PRO	2470	1250
Novartis, Switzerland (sub)	Basel	Private	2323	1300
University of Fribourg	Fribourg	University	2274	1318
Universite de Neuchatel	Neuchâtel	University	1978	1455

Annex 3 - List of the main funding programmes

Name of the funding programme	rch Funding Organi	Timeline	Budget (m CHF, 2012)	Target group
SNF National Centers of Competences in research	SNF	2000-	52'034	Public, mostly higher education
SNF National Research Programmes	SNF	1975-	19114.15711	Public, mostly higher education
Sinergia programme	SNF	2008-		Public, mostly higher education
Research project	SNF	1952-		Public, mostly higher education
CTI projects	CTI	1944-		Public, mostly higher education, private partners participate without funding

Annex 4 - Evaluations, consultations, foresight exercises

Monitoring and evaluation of the Swiss R&I system are undertaken regularly and are taken into account in the national R&I strategy. The most important evaluation for the preparation of the R&I strategy 2017-2020 are listed below (source: Schweiz. Bundesrat 2016).

Monitoring

SKBF (2014). Bildungsbericht Schweiz 2014. Aarau: Schweizerische Koordinationsstelle für Bildungsforschung.

This report provides a comprehensive analysis of the Swiss educational system from primary school to continuing education, including statistical data and scientific analysis on the Swiss educational policy.

SBFI (2016). Forschung und Innovation in der Schweiz 2016. Bern:

This is comprehensive and in-depth report on the Swiss research and innovation system: it includes an up-to-date system description, a set of monitoring indicators and four in-depth studies.

Impact evaluation

- Professional education

Econcept (2014). Pilot Project Swiss VET Initiative India: Evaluation. Zürich: Econcept

Econcept und Universität Zürich (2015). Evaluation Berufsbildungsforschung SBFI, Schlussbericht. Zürich: Econcept und Universität Zürich.

Econcept (2015). Konzept zur Stärkung der BM, Schlussbericht. Zürich: Econcept.

SBFI (2014). Berufsabschluss und Berufswechsel für Erwachsene, Bestehende Angebote und Empfehlungen zur Weiterentwicklung. Bern: SBFI.

- Higher Education

– WBF (2015). Zwischenevaluation des ETH-Bereichs in der Leistungsperiode 2013–2016. Bern: WBF.

- Research and innovation promotion

Universität Zürich (2013). Wirkungen innovationspolitischer Fördermassnahmen. Zürich: Universität Zürich.

SBFI (2015). Umsetzung der europäischen F&E Programme Eurostars, AAL und EDCTP in der Schweiz: Akteursanalyse. Bern: SBFI.

SWIR (2015). Examen systématique des effets de l'instrument Pôles de recherche nationaux PRN (série 1, 2001–2013). Rapport final, Document CSSI 7/2015, Bern: SWIR.

SWIR (2015). Evaluation des Schweizerischen Nationalfonds in Bezug auf die strategische Förderung von Forschungsinfrastrukturen und Fachgebieten. Schlussbericht, SWIR Schrift 5/2015, Bern: SWIR.

FHNW (2015). Evaluation of the existing Swiss institutional R&D funding instruments for the implementation of the space-related measures. Olten: FHNW.

- Other evaluations

SBFI (2014). Massnahmen zur Förderung des wissenschaftlichen Nachwuchses in der Schweiz. Bericht in Erfüllung des Postulats WBK-SR (12.3343). Bern: SBFI.

Interface (2013). Evaluation der ch-Agentur und der Implementierung der EU-Programme «Lebenslanges Lernen» und «Jugend in Aktion» in der Schweiz. Luzern: Interface

SBFI (2015). Leistungs- und Wirkungsanalyse des swissnex Netzwerks. Bern: SBFI.

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